SHOUT
SHARE
IT

BR1
1511

S-ES-B

HARVARD UNIVERSITY

VE RI TAS

LIBRARY

OF THE

MUSEUM OF COMPARATIVE ZOÖLOGY

38,846
Bought

July 20, 1942,

PROCEEDINGS

OF THE

BRISTOL NATURALISTS' SOCIETY.

NEW SERIES, Vol. VI. (1888 91).

PROCEEDINGS

OF THE

BRISTOL NATURALISTS' SOCIETY.

EDITED BY THE HONORARY SECRETARY.

LIBRARY
MUS. COMP. ZOÖLOGY,
CAMBRIDGE, MASS.

"*Rerum cognoscere causas.*"—VIRGIL.

BRISTOL: JAMES FAWN & SON.

PRINTED FOR THE SOCIETY.

MDCCCXCI.

7 13/6

38,846

Museum of Comparative Zoology
JUL 20 1942
LIBRARY

INDEX TO VOL. VI.

PAGE

Bees, Some British Wild 213
Birds exhibited at Meetings 115, 160, 161, 244
Blackbirds, Observations on a Pair of 202
Brislington Cutting, The 165
Bucknall, Cedric, Mus.Bac.:
  The Fungi of the Bristol District 28, 189, 274
  Index to Bristol Fungi 425
Burder, George F., M.D., F.R.Met.Soc.:
  The Frosts of Recent Years 294
  Rainfall at Clifton, 1888 37
  " " 1889 195
  " " 1890 287

Camel's Stomach, Notes on the Water-cells of the (Abstract) . 118
Cassava 418
Cornish Viaducts 217
Cotterell, Albert P. I., Assoc. M. Inst. C.E.:
  Some Remarks on Sewerage Systems 93
  Cornish Viaducts 217
Crawford, G. E., B.A.: The Eiffel Tower 142

Dallinger, Rev. W. H., LL.D., F.R.S.: On Putrefactive Organisms (Abstract) 86
Duncan, William, L.R.C.P.:
  "Trigonocephalus lanceolatus" (The Fer-de-Lance) . 44
  Cassava (Abstract) 418

Edgeworth, Francis H., M.B., B.Sc., B.A.: Hypnotism . . 359
Eiffel Tower, The 142

Fer-de-Lance 44
Flora of the Bristol Coalfield 18

PAGE

Flowers and Foliage of Tropical and Temperate Regions, Suggestions as to the Causes of the Difference in Colour between the . . . 121
Formulæ for Strength of Fire-box Girder Stays, Investigation of the Board of Trade's . . . 232
Francis, H. A., F.R.M.S.: Some British Wild Bees . . . 213
Frosts of Recent Years, The . . . 294
Fungi of the Bristol District. Part XI. . . . 28
„ „ „ „ XII. . . . 189
„ „ „ „ XIII. . . . 274
„ „ „ Index to . . . 425

Griffiths, G. C., F.E.S.: Mimicry amongst the Lepidoptera. . 79

Harrison, A. J., M.B. Lond.: Do Snakes Fascinate their Victims? 67
Harvey, J. W. I.: Investigation of the Board of Trade's Formulæ for Strength of Fire-box Girder Stays . . . 232
Heliothis scutosa, A Few Notes on . . . 34
Hypnotism . . . 359

Jecks, Charles: Suggestions as to the Causes of the Difference in Colour between the Flowers and Foliage of Tropical and Temperate Regions . . . 121

Landslips . . . 301
Language and Race . . . 390
Leonard, H. Percy:
  Observations on a Pair of Blackbirds . . . 202
  Observations on British Mice . . . 342

Mann, W. Kempster: A Few Notes on Heliothis scutosa . . 34
McCurrich, John Martin, M.A., Assoc. M. Inst. C.E.: The Warehousing of Grain . . . 124
Mendip Notes . . . 169
Mice, Observations on British . . . 342
Mimicry amongst the Lepidoptera . . . 79
Morgan, Prof. C. Lloyd, F.G.S.:
  The Geology of Tytherington and Grovesend . . 1
  On the Perceptions of Animals (Abstract) . . . 116
  The Brislington Cutting . . . 165
  Mendip Notes . . . 169
  The Geology of the Wick Rocks Valley . . . 183
  The Nature and Origin of Variations . . . 249

PAGE

Mountain Building, On Mr. Mellard Reade's Work on . . 63

Pearson, H. W., M.I.C.E.: Some of the Water-bearing Strata, and Wells sunk in same 327
Perceptions of Animals, On the 116
Phenological Observations for 1890 278
President's Address. 249
Prowse, Arthur B., M.D., F.R.C.S.:
  Voice, Language, and Phonetic Spelling . . . 153
  Language and Race 390
Putrefactive Organisms, On 86

Rainfall at Clifton, 1888 37
" " 1889 195
" " 1890 287
Reports of Meetings, General and Sectional . 160, 243, 421
Richardson, Charles, C.E.: Landslips 301
Rintoul, D., M.A., Cantab.:
  Observations of Temperature at Clifton, 1888 . . 40
  " " " 1889 . . 198
  " " " 1890 . . 290

Saunders, Rev. M. B.: On Mr. Mellard Reade's Work on Mountain Building 63
Sewerage Systems, Some Remarks on 93
Smith, G. Munro, L.R.C.P., Lond., M.R.C.S.: Notes on the Water-cells of the Camel's Stomach (Abstract) . . . 118
Snakes, Do they Fascinate their Victims? 67

Talpa; or, Remarks on the Habits of the Mole 56
Temperature at Clifton, 1888 40
" " 1889 198
" " 1890 290
Trigonocephalus lanceolatus 44
Tytherington and Grovesend, The Geology of 1

Variations, The Nature and Origin of 249
Voice, Language, and Phonetic Spelling 153

Warehousing of Grain, The 124
Water-bearing Strata, and Wells sunk in same 327
White, James Walter, F.L.S.: Flora of the Bristol Coal-field . 18
Wick Rocks Valley, The Geology of the 183

NEW SERIES, Vol. VI., Part I. (1888-9). Price 4s.

PROCEEDINGS

OF THE

BRISTOL NATURALISTS' SOCIETY.

EDITED BY THE HONORARY SECRETARY.

NATURALISTS'
BRISTOL
SOCIETY

"*Rerum cognoscere causas.*"—VIRGIL.

BRISTOL:

PRINTED FOR THE SOCIETY.

MDCCCLXXXIX.

NEW SERIES, Vol. VI., Part I. (1888–9). Price 4s.

PROCEEDINGS
OF THE
BRISTOL
NATURALISTS' SOCIETY.

EDITED BY THE HONORARY SECRETARY.

NATURALISTS
BRISTOL
SOCIETY

"*Rerum cognoscere causas.*"—VIRGIL.

BRISTOL:

PRINTED FOR THE SOCIETY.

MDCCCLXXXIX

TABLE OF CONTENTS.

NEW SERIES, VOL. VI., PART I.

PAGE

The Geology of Tytherington and Grovesend. By Prof. C. Lloyd Morgan, F.G.S. 1

Flora of the Bristol Coal-field. By James Walter White, F.L.S. . 18

The Fungi of the Bristol District. By Cedric Bucknall, Mus. Bac. 28

A Few Notes on Heliothis Scutosa. By W. Kempster Mann . . 34

Rainfall at Clifton in 1888. By George F. Burder, M.D., F.R. Met. Soc. 37

Observations of Temperature at Clifton, 1888. By D. Rintoul, M.A., Cantab. 40

"Trigonocephalus Lanceolatus": Notes on the West Indian "Fer-de-Lance." By Dr. William Duncan 44

Talpa; or, Remarks on the Habits of the Mole. By C. J. Trusted 56

On Mr. Mellard Reade's Work on Mountain Building. By Rev. M. B. Saunders 63

Do Snakes Fascinate their Victims? By Dr. A. J. Harrison . . 67

Mimicry amongst the Lepidoptera. By G. C. Griffiths 79

On Putrefactive Organisms. By the Rev. W. H. Dallinger, LL.D., F.R.S. 86

Some Remarks on Sewerage Systems. By Albert P. I. Cotterell, Assoc. M. Inst. C.E. 93

Birds Exhibited at Meetings 115

On the Perceptions of Animals. By Prof. C. Lloyd Morgan . . 116

Notes on the Water-cells of the Camel's Stomach. By G. Munro Smith, L.R.C.P. Lond., M.R.C.S. 118

Suggestions as to the Causes of the Difference in the Colour between the Flowers and Foliage of Tropical and of Temperate Regions. By Charles Jecks 121

The Warehousing of Grain. By John M. McCurrich, M.A., Assoc. M. Inst. C.E. 124

The Eiffel Tower. By G. E. Crawford 142

Voice, Language, Phonetic Spelling. By Arthur B. Prowse, M.D., F.R.C.S. 153

Reports of Meetings, General and Sectional 160

Wm Sanders

William Sanders, F.R.S.

FEW members of the Bristol Naturalists' Society will need to be reminded of the eminent services to science which have given to the memory of the Society's first President a claim upon our respectful regard. Nevertheless, in presenting a portrait of Mr. Sanders after the lapse of sixteen years, it may be appropriate to reproduce the following sentences taken from the Anniversary Address of the then President of the Geological Society, Mr. John Evans, F.R.S.

"By the death of Mr. William Sanders, F.R.S., on the 12th of November, 1875, the Society has lost another of its early members, and one who for upwards of forty years of his life was intimately associated with the most distinguished men connected with geological science.

"Mr. Sanders, who was born on the 12th of January, 1799, was a native of Bristol; and to the study of the geology of the neighbouring country he devoted his life.

"At the commencement of his scientific career he was the friend and companion of Prof. Phillips in his geological survey of North Devon and Cornwall. But his principal work was the preparation and construction of an elaborate geological map of the district comprised within the Gloucestershire and Somersetshire coal-field, on the scale of four inches to the mile. This work, which extended over fifteen years, was undertaken at the instigation of Sir Henry de la Beche and Prof. Phillips. Besides this map, he published some measured sections of the extensive cuttings on the Bristol and Exeter Railway, and on the line from Bristol to

Bath. On these sections, which were drawn to scale, every detail, however minute, that was of any physical or palæontological importance, is accurately delineated; and their value remains undiminished, even after the lapse of thirty-five years.

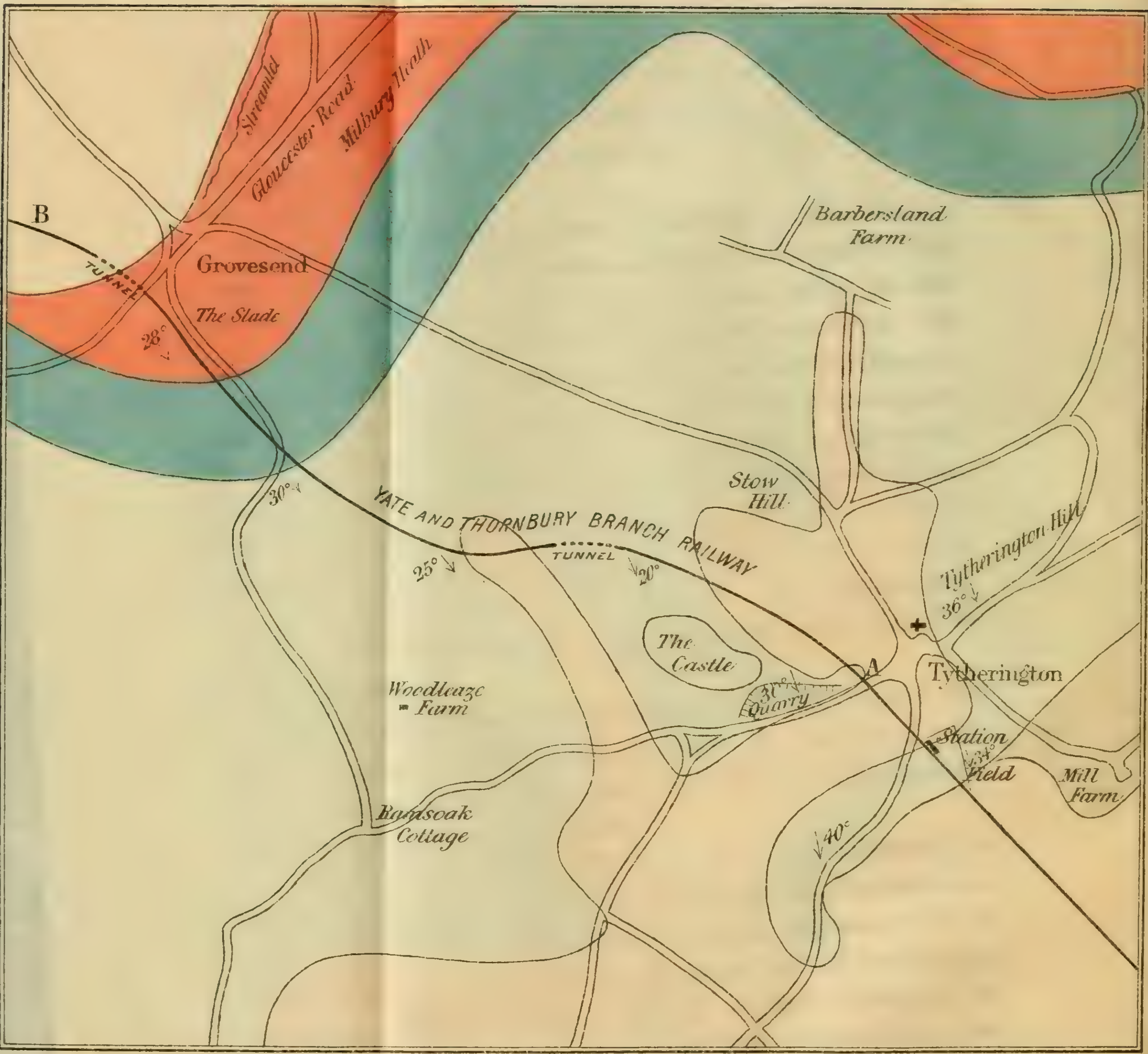
"Mr. Sanders, by his intimate knowledge of the Mendip area, was able to render valuable assistance to his native town in connection with its water-supply, and also during the survey of the city with reference to its sanitary condition. He was also for upwards of thirty years the Honorary Secretary to the Museum of Natural History attached to the Philosophical Society and Institution of Bristol, and spared neither time, trouble, nor expense in carrying out its legitimate objects. Those who visited Bristol at the last meeting of the British Association will remember the just pride which he took in the geological collections in the Museum. Mr. Sanders was also an ardent student of mineralogy, and well versed in crystallography.

"He became a Fellow of this Society in 1839, and of the Royal Society in 1864. Several papers on geological subjects were read by him before the British Association between the years 1840 and 1849."

To the above well-deserved tribute it is only necessary to add, as indicating the estimation in which Mr. Sanders was held by his fellow-citizens as the foremost representative of science amongst them, that on the foundation of our Society in the year 1862 he was by common consent chosen as its first President, and year after year was re-elected to the same office, until the connection was severed by his lamented death.

ınd

ks off
ation.
to the
nnant
ange-
flat to
e see
of the
runs
higher
inlet
ge of
which
ngton
is the
. As
to the
ide is
dleaze


Streamlet
Gloucester Road
Milbury Heath
B
TUNNEL
Grovesend
The Slade
28°
Barbersland Farm
30°
YATE AND THORNBURY BRANCH RAILWAY
TUNNEL
25°
20°
Stow Hill
Tytherington Hill
36°
The Castle
A
Tytherington
30°
Quarry
Woodleaze Farm
Station
34°
Field
Mill Farm
Ramsoak Cottage
40°

LAVARS, LITH. BROAD S^T BRISTOL.

SCALE_4 Inches to One Mile.

Geological Map

(Modified from W^m Sanders)
of the
Tytherington_Grovesend District.

▭ *Trias.*

▭ *Millstone Grit.*

▭ *Carboniferous Limestone (with Upper Transition Beds)*

🟦 *Lower Transition Beds.*

🟥 *Old Red Sandstone.*

The Geology of Tytherington and Grovesend.

By Prof. C. LLOYD MORGAN, F.G.S.

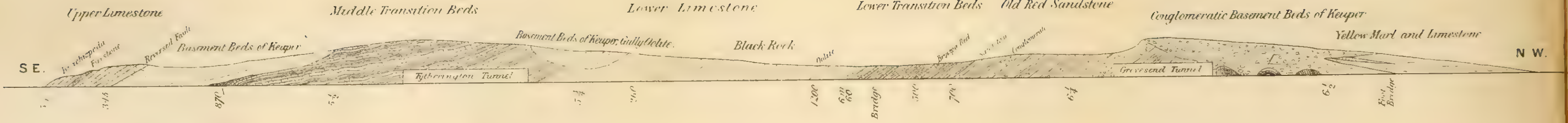
1. *General Features of the District.*

THE branch line of railway to Thornbury breaks off from the Midland line to Gloucester, at Yate Station. It then takes a curved course over strata belonging to the Coal-measure series, with occasional exposures of Pennant Sandstone by the rail-side, through Iron Acton to Rangeworthy; after which it runs N.W. across a Triassic flat to Tytherington. Alighting at Tytherington Station, we see before us the Mountain Limestone which forms part of the northern rim of the Bristol coal-field, and along which runs the northern water-shed of the Avon basin. The higher ground of the Limestone is broken into by a deep inlet occupied by Triassic beds, on which the little village of Tytherington is for the most part built. The valley which thus runs up into the Limestone separates Tytherington Hill on the east from a hill to the west on which runs the oval rampart of a British camp known as the Castle. As is usual in such cases, the rampart is best marked to the north, where the natural defence of the steep hill-side is absent. West of the Castle Hill, between it and Woodleaze

Farm, is another valley occupied by Triassic strata. The southern slope of Castle Hill is being eaten into by a large quarry, worked by Mr. Hardwicke, of Tytherington.

Beyond the station the line of rail skirts the north-eastern side of the Castle Hill in a gradually deepening cutting, in which Triassic strata are seen resting on the upturned edges of Mountain Limestone. Then curving to the east, so as to run nearly along the strike of the Palæozoic strata, it enters the Tytherington tunnel; on emerging from which Triassic beds are again seen filling a denuded hollow in the Mountain Limestone. Turning northwards, the cutting then runs nearly across the edges of the Palæozoic strata, until, close to a stone bridge near Grovesend, the grass-covered slopes of the cutting indicate the incoming of the softer beds, which are transitional between the Carboniferous series and the Old Red Sandstone. Stronger and harder beds of Old Red Sandstone crop out before the Grovesend Tunnel, at the northern end of which the Old Red Sandstone, in places vertical, and further on showing the summit of an anticlinal roll, is overlain by hard Basement Beds of the Trias which stand in the cutting as a vertical wall. These are succeeded by argillaceous limestones and Triassic Marls, from which the line of rail emerges, to run over comparatively flat and low-lying Old Red Sandstone to Thornbury.

The hamlet of Grovesend stands at the head of a little valley of denundation draining N. by E. Into the head of this valley the Gloucester Road over Milbury Heath dips. Immediately under the road is the tunnel mouth, and above the road is a mural face of hard dense Old Red Sandstone, partly hidden by walling. Towards Bristol the road rises over Old Red Sandstone, and then dips into a depression caused by the incoming of the softer Lower


Upper Limestone
Middle Transition Beds
Lower Limestone
Lower Transition Beds
Old Red Sandstone
Conglomeratic Basement Beds of Keuper
Yellow Marl and Limestone
S E.
N W.
Brachiopoda
Freestone
Reversed Fault
Basement Beds of Keuper
Basement Beds of Keuper, Gully Oolite.
Black Rock
Oolite
Brazen Red
Conglomerate
Tytherington Tunnel
Grovesend Tunnel
870
1200
Bridge
500
70
6½
Foot Bridge

THE TYTHERINGTON — GROVESEND SECTION

Horizontal Scale 528 feet to one Inch or 10 Inches to One Mile

Vertical Scale about 10 times Horizontal

LAVARS LITHO 51 BROAD STREET BRISTOL

Limestone Shales. Towards Gloucester it rises along the Old Red Sandstone, which, flanked by Triassic beds, overlooks at first the stream-cut valley, and then the low-lying country which stretches by Thornbury to the Severn. The view from this road, before it dips on to the Trias, near Buckover, is superb.

The road from Grovesend to Tytherington rises over Old Red Sandstone, and then, after dipping into Lower Limestone Shales, passes across the Mountain Limestone to Stow Hill, when it drops steeply into the Triassic inlet on which Tytherington is situated.

2. *The Railway Section between Tytherington and Grovesend.*

I have to thank the Rev. H. H. Winwood, M.A., F.G.S., of Bath, for introducing this section to my notice. We visited the section together several times, and once in company with Mr. W. L. Meredith, C.E., F.G.S. These two gentlemen are publishing, in the Proceedings of the Cotteswold Field Club, a section, prepared by Mr. Meredith, and descriptive notes supplied by Mr. Winwood. The section published herewith is based on Mr. Meredith's,* the horizontal scale being reduced to one-fourth, while the vertical scale remains the same. My reading of the section differs somewhat from that given by Mr. Winwood, but I have to thank him for having, with great courtesy, sent me proofs of his Cotteswold paper, in which he recorded some of the measurements we made together.

The section,—nearly one mile and a half in length,—runs between the points A and B on the map which accompanies this paper. It will be noted that the line between these points does not run straight, but makes an S-like curve. *The section is therefore not at right angles with the strike of the Palæozoic strata.* We may conveniently divide it into the following sub-sections:—

---

* By the kind permission of these gentlemen, and of the President and Secretary of the Cotteswold Field Club.

Sub-section 1.—From the 5¼-mile post to 345 feet, where the Mountain Limestone is cut off by a reversed fault. The strata here dip from 30° to 34° S. by E., the line running N.W.

Sub-section 2.—From the reversed fault to the 5½-mile post, where the Palæozoics, which emerge at 710 feet, are overlain by the Basement Beds of the Trias.

Sub-section 3.—From the 5½ to the 5¾-mile posts. The line here runs nearly along the strike of the strata, which dip 16° to 25° S. by E. to S.S.E

Sub-section 4.—From the 5¾-mile post to the mouth of the Grovesend tunnel. The average dip is about 28° E.S.E., and the line runs N.W. by N.

Sub-section 5.—From the N.W. end of the Grovesend tunnel to the end of the section. Old Red Sandstone, with varying dip, is overlain by solid conglomeratic Basement Beds of the Trias.

Sub-section 1.—The strata in this sub-section are well exposed in Mr. Hardwicke's quarry. To the south-west they are overlain by Triassic beds. They may be thus grouped:—

	ft.	in.
Yellow and Blue Limestones, with *Producti* and *Lithostrotion*	60	0
Silicious Limestone (2 beds); locally called "Firestone"	9	3
Blue Limestone with shaley partings (*Lithostrotion* and *Producti*)	75	9
	145	0

The silicious limestones are remarkable beds, very dense and hard in the solid; the upper bed, which is the more silicious, weathering at surface to a friable red sandstone. A fragment of this treated with dilute hydrochloric acid effervesces briskly, but on the cessation of the action of the acid, still retains its form and consistency; if then treated with concentrated hydrochloric and boiled, the acid is stained deeply yellow by ferric chloride, and there remains a white sugary sandstone. Under the lens the rock is seen to be almost entirely composed of grains of detrital quartz, cemented by calcareous matter, and with here and there dark-red scales of ferric oxide. After treatment with acid, the lens shows that the rock is sugary from the removal of the calcareous matter and iron scales. The percentage of insoluble matter, after treatment with acid, is 72·05. The stone is used for road-metalling, and has a resistance to a crushing stress of 14,694 lbs. to the square inch, as determined by Messrs. Kirkaldy.*

In the midst of the "Fire-stone" there are seen, where the beds outcrop at the surface, lenticular masses of *Lithostrotion irregulare*, and on the dip-slope of Limestone, exposed by the removal of the overlying "Fire-stone," fine branching stocks of the same coral are abundant. In the lower bed of "Fire-stone" Mr. Winwood obtained *Spirifera octoplicata* and *Athyris globularis*. It is, however, exceedingly difficult to obtain satisfactory fossils from this quarry, though Producti and Lithostrotion are abundant. About 15 feet above the "Fire-stone" occurs a bed, the surface of which, where exposed, is crowded with Brachiopods and *Euomphali* (?); all, however, in bad condition for extraction or recognition. Both above and below the "Fire-stone" there are black bands of limestone giving a bituminous odour when freshly broken.

---

* "Highway Management. Proceedings of a Conference held at Gloucester, 1886." Appendix I., page 50.

It is difficult to assign with any degree of certainty the position of the "Fire-stone" beds in the Limestone series, owing to the reversed fault which breaks the continuity of the strata. The same beds appear, however, on Tytherington Hill, so that their strike can be laid down on the map, while the point where they cross the line can be readily determined. In the field near the Station beds of somewhat silicious limestone occur; they probably belong to the Upper Limestone Shales, for in the barton of Mill Farm (see map), beds of grit are exposed, overlain by Basement Beds of the Trias. The distance from the strike of the "Fire-stone" beds to the uppermost Limestone bed visible in this field, measured across the dip, is 750 feet. The dip of the beds is 34°. Calculating on this basis, I find the bed in the Station field to have a position of about 420 feet (vertically) higher in the series than the "Fire-stone."

Sub-section 2.—A very interesting feature of the section is the reversed fault. It is unfortunate that no sketch-section of the beds here shown was published at the time when the line was formed. I give one (Fig. 1) as it now appears. The beds of Mountain Limestone have been thrust up along their dip faces over Basement Beds of the Trias. The line of fault, as seen, makes with the horizontal an angle of 20°. The irregular nodules at *a* consist of marly limestone. They protrude from yellowish-white calcareous marl. It is strange to see Mountain Limestone overlying, apparently unconformably, beds of a far more recent age. The existence of the fault, however, at once explains matters. There are no data for estimating the throw of the fault, but I do not suppose it is of any considerable magnitude.

Beyond the fault the Basement Beds of the Trias lie in a gentle dip. About 525 feet from the beginning of the section the Palæozoic beds rise unconformably beneath them, and come to surface about 60 feet from the 5½-mile post, the Triassic beds here dying out at surface, and not reaching as far as the tunnel mouth, as shown in Mr. Meredith's section. Soon after the Palæozoics come in, there is, beneath the marly limestones of the Basement Beds, a pocket of marl, described by Mr. Winwood, and specially figured as "sand" by Mr. Meredith. Of the Basement Beds of the Trias I shall speak again under that head (p.14).

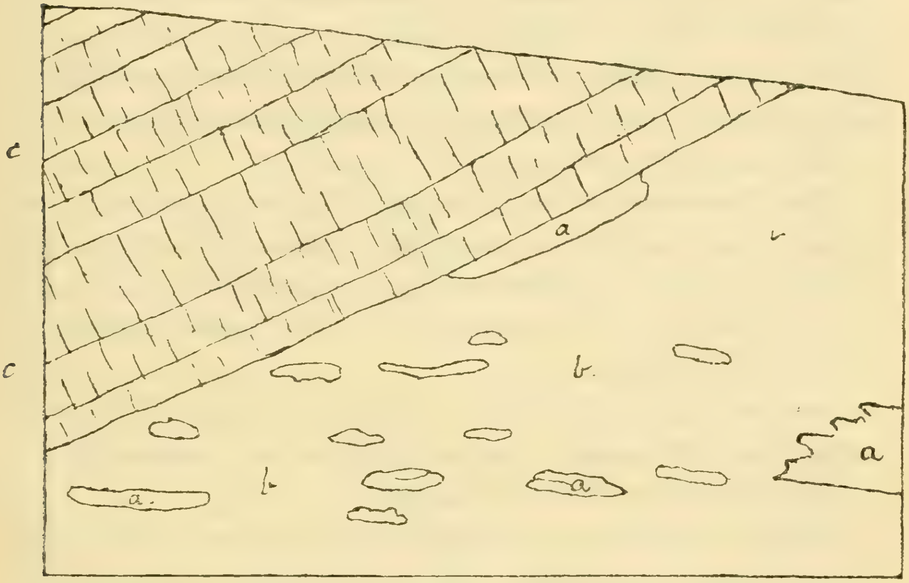


Fig. 1.

Sketch Section to show Mountain Limestone thrust up over Basement Bed of Keuper by reversed fault.

a a, Marly Limestone; *b b*, Yellowish White Marl; *c c*, Mountain Limestone.

Sub-section 3.—This includes the Palæozoic beds from where they appear beneath the Trias to the oolitic limestone beyond the tunnel mouth. They dip somewhat irregularly from 16° to 25° S. by E. to S.S.E. And since the line of rails in the tunnel runs nearly east and west (5° N. of W. and 5° S. of E.), this part of the section runs nearly, but not quite, along the strike of the beds. As seen in the section, the thin bands of limestone are thrown into slightly waving folds; similar folds are noted by Mr. Winwood as occurring in the tunnel.

The limestones are, for the most part, thinly-bedded, close-grained, and argillaceous, mottled or streaked with green, pink, and purple. Between them are partings of red, pink, and grey shales. We measured 118 feet of these beds before the tunnel mouth.

At the other end of the tunnel, shales and fine-grained argillaceous limestone, weathering white, are seen overlying very dense and solid oolitic limestones.

I believe the shales and argillaceous limestones here seen form a continuous series with those on the other side of the tunnel. It is impossible to estimate with accuracy the thickness of beds hidden by the tunnel. But seeing how nearly it runs along the strike of the strata, I cannot think that there are more than 20 or 30 feet. I am convinced that Mr. Winwood is in error in assigning a thickness of 178 feet to the beds hidden by the tunnel.

I estimate the total thickness of the beds above the oolitic limestone in this sub-section at 150 to 160 feet.

Just beyond the tunnel mouth the cutting is, on the south side, walled up. This wall covers the entrance to a great cavern, or underground watercourse, which dipped down southwards, and ran for a distance of two or three hundred feet. A small hollow, about 7 feet deep by 3½ wide, has recently been holed into on the north side of the line; and a somewhat larger cavity, 20 or 25 feet long, has been disclosed by Mr. Hardwicke's quarrying in the oolitic limestone.

On the further side of the Tytherington tunnel the Palæozoic strata are again overlain by Triassic beds, which occupy a denuded depression. I shall speak of these further on.

Sub-section 4.—The oolitic limestones which appear shortly after the line emerges from the Tytherington tunnel are dense strata in which the bedding is inconspicuous. They are being quarried by Mr. Hardwicke. The oolitic structure is very clearly marked, and they closely resemble the Gully Limestone of the Avon section at Clifton. I estimate their thickness at 150 feet.

They are followed by a series of about 500 feet of bedded limestones, dark in colour, with strong bituminous odour when freshly broken, and largely composed of crinoidal ossicles. They contain, especially in the lower beds, abundant *Spirifers ;* we also found a gastropod, probably *Loxonema.* About 75 feet before the 6-mile post is a bed of oolitic limestone. Small quantities of Galena were found near here associated with Barytes.

These limestones are succeeded, 150 feet from the stone bridge, by the more shaley beds of the Lower Limestone Shales. Beyond the bridge they are somewhat obscured by grass, but Mr. Meredith kindly had them cleared near the line. About 250 feet from the bridge occurs the Bryozoa bed, far less marked than in the Avon section below Cook's Folly, but still readily recognisable—polyzoa (*Rhombopora*), encrinite ossicles, and other organic remains being converted oxide of iron.

I confess that it gave me great pleasure to find this bed in the Tytherington section. It has long been known in the Avon section. I subsequently proved its existence at Charlton, near Portbury, at Portishead, and in Woodhill

Bay. I have not yet proved it in the Mendips; but here we have it on the northern borders of the Avon Basin near Grovesend.

It is difficult here, as elsewhere, to determine where the so-called Lower Limestone Shales pass into the Old Red Sandstone. The series is essentially a transition series. Above, it shades into the Lower Limestones of the Carboniferous; below, it shades into the Old Red Sandstone. Above, there are shales with limestones; below, there are shales with sandstones. I have carefully gone over the beds, testing them with acid, and am disposed to place the incoming of the Old Red Sandstone at a point 480 feet from the bridge. Here occurs a band of hard, close-grained sandstone. Below it, none of the beds show any effervescence with acid; shortly above it, they give the characteristic calcareous reaction. The bed I speak of is 120 feet from where the conglomerate with milky quartz, shown on Mr. Meredith's section, crosses the line. I estimate the thickness of the Lower Limestone Shales between the points I have indicated at 315 feet.

The succeeding beds to the tunnel mouth consist of red shales, sandstones, and conglomerates, with milky quartz abundant. Just at the tunnel mouth are hard conglomeratic beds; and a similar bed is seen, as before mentioned, above the road beneath which the tunnel passes.

Sub-section 5.—On emerging from the tunnel coarse conglomeratic and brecciated Basement Beds of the Trias are seen resting on the vertical edges of upturned Old Red conglomerates and shales (see Fig. 2). Of the Basement Beds I shall speak presently. Here I need only note that there are two other places where the Old Red is exposed at the base of the section. The first of these begins 265 feet from the tunnel mouth, and lasts 110 feet. It shows the summit of an anticlinal roll of the Palæozoic beds. The second (not noted in Mr. Meredith's section) occurs a little before the $6\frac{1}{2}$-mile post, and shows the Old Red beds dipping at an angle of about 60° to the west.

3. *The Tytherington and the Clifton Section Compared.*

Several readings of the beds in the classical Clifton section of the Avon gorge have been given, of which the most recent is that by Mr. E. Wethered, in his valuable paper "On Insoluble Residues from the Carboniferous-Limestone Series at Clifton" (Q.J.G.S., May, 1888). The classification of the beds he adopts may be summarized in the following table:—

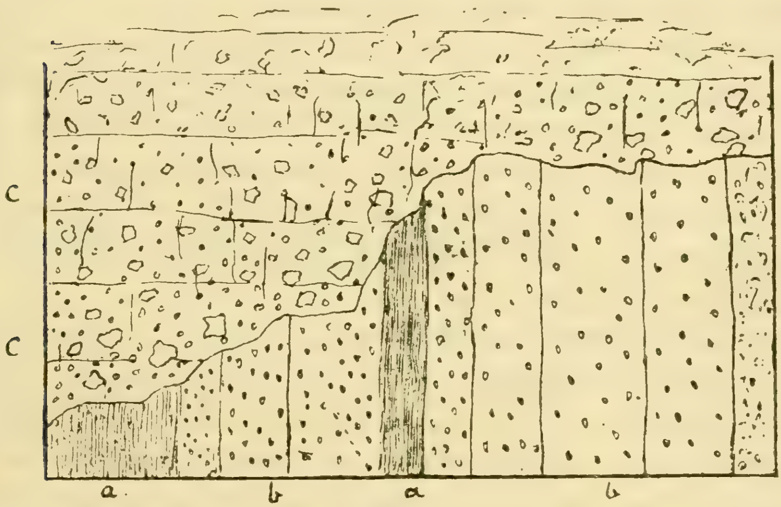


Fig. 2.

Sketch Section, northern end of Grovesend Tunnel, to show Basement Beds of Keuper resting on upturned edges of Old Red Sandstone with strike N.E. by N.

a a, Red shaley beds of O. R. S.; *b b*, Conglomeratic beds of O. R. S. with pebbles of milky quartz; *c c*, Conglomeratic and brecciated Basement Beds of Keuper, with milky quartz pebbles from O. R. S., and brecciated fragments of O. R. S., with some Mountain Limestone.

		Feet.
Upper Limestones		100
Middle Limestones	Main portion *Mitcheldeania*-beds Oolitic beds, 100 feet	1620
Lower Limestones	Black Rock, 490 feet Lower Limestone Shales, 500 feet	990
	Total	2710

The Upper Limestones are the beds often spoken of as Upper Limestone Shales, and described by Sir H. de la Beche (Mem. Geol. Surv., vol. i., p. 129) as Upper Mixture of Sandstones, Marls, and Limestones. Sir Henry gives the thickness of these beds as 400 feet. But the boundaries of these transition beds are always difficult to determine, and this accounts for the discrepancy between the thickness of these beds as given by him and that given by Prof. Hull, which Mr. Wethered adopts.

The oolitic beds are those seen in the old quarry at the bottom of the gully. Concerning their position, Mr. Wethered speaks with a somewhat uncertain note. On page 187 he writes: "At the top of the Black Rock series there is clear evidence of an alteration of conditions under which the limestone was being deposited; this is indicated by a thickness of about 100 feet of oolitic limestone, which closed what may be termed the 'Local Encrinite Period,' and preceded conditions extending over a length of time difficult to estimate, during which a great thickness of strata was deposited in which crinoidal remains are few in number and small in size." Here, therefore, he makes the oolitic beds bring to a close the Lower Limestone series. But on the table he gives (p. 189) he places the oolitic beds at the base of the Middle Limestone.

The *Mitcheldeania*-beds are those which I described in these Proceedings (vol. iv., part 3) as Middle Limestone

Shales. The subjoined table gives my own classification of the series in the Avon section. The estimated thicknesses are given in round numbers. I place the line of division between the Upper Transition Beds and the Upper Limestone at a point 340 feet on the Bristol side of where the new zigzag path crosses the rail. The points at which the boundaries of the strata cross the Port and Pier railway were determined on the six-inch Survey map. Through these points lines of strike were laid down; the strata were measured across the outcrop at right angles to the line of strike; and the thicknesses calculated for a mean dip of 27½°.

The Avon Section at Clifton.

		Feet.
Upper Transition Beds (Upper Limestone Shales)		400
Upper or Lithostrotion Limestone		800
Middle Transition Beds (*Mitcheldeania*-beds)		200
Lower or Encrinital Limestone	The Gully Oolite, 100 feet The Black Rock, 550 feet	650
Lower Transition Beds (Lower Limestone Shales)		320
Total		2370

In the Tytherington section the continuity of the beds is broken by the reversed fault. There can be no doubt, however, that the beds in Mr. Hardwicke's quarry belong to the Upper or Lithostrotion Limestone. The bituminous beds on either side of the so-called "Fire-stone" may very possibly be equivalent to the similarly bituminous beds of the Great Quarry of the Avon section. But I know of no "Fire-stone" in that quarry.

The thin-bedded argillaceous limestones which come in beneath the Trias in Sub-section 3 are, I take it, near the top of the Middle Transition (*Mitcheldeania*) Beds. The Gully Oolite is well represented just beyond the Tytherington tunnel, and is followed by the Black Rock limestones.

The following table gives the thicknesses for comparison with the Clifton Section.

The Tytherington Section.

Upper Transition Beds (in Station Field)		?
Upper or Lithostrotion Limestone (in Mr. Hardwicke's quarry)		145+
Middle Transition (*Mitcheldeania*) Beds		160
Lower or Encrinital Limestone	The Gully Oolite 150 The Black Rock 500	650
Lower Transition Beds		315
		1275+

4. *The Basement Beds of the Keuper.*

It is well known that in the Bristol area, the Permian Strata of other parts of England, and the Bunter beds of the Trias, so well developed in Cheshire, are both wanting, while the Keuper beds are much reduced in thickness. During the long period in which the Permian, Bunter, and part of the Keuper were being deposited in other parts of England, the Bristol area was dry land, and was suffering denudation.

As the Keuper lake extended into the Bristol area, there was formed, along its margin and round the islands which broke its surface, a deposit known as the Dolomitic Conglomerate. The name is an unfortunate one; for it is not always markedly dolomitic, and the angular fragments it so often contains give it rather the character of a breccia than a conglomerate. And if we work over the patches of rock marked Dolomitic Conglomerate on the survey map, we cannot fail to be struck by the very variable nature of the deposit, as, indeed, is to be expected from its mode of origin. At times it is a very coarse breccia, with huge fragments of Old Red Sandstone, Millstone Grit, or Mountain Limestone (according to the nature of the Palæozoics on or near which it rests) cemented in a ferruginous and calcareous matrix. At other times it is a yellowish argillaceous and magnesian limestone, with comparatively small brecciated fragments of Mountain Limestone. I have found it exceedingly confusing to students to call this variable deposit by the common name of Dolomitic Conglomerate. And I therefore venture to suggest that the beds underlying the Keuper Marls, and resting on the Palæozoic rocks in our area, should be called the Basement Beds of the Keuper, or Basement Beds of the Trias.

In the district under consideration, and in the section I have been describing, the variable nature of these Basement Beds is well exemplified. In the barton of Mill Farm the grit is overlain by a ferruginous limestone. In Sub-section 2, after the reversed fault, the Basement Beds consist of yellow marls, with bands of hard argillaceous limestone. An analysis of this limestone gives only 8·41 per cent. of argillaceous residue after treatment with dilute acid. Of magnesium carbonate there is 9·13 per cent.

On emerging from the Tytherington tunnel, Triassic beds are again seen resting in the main on the oolitic beds of the Carboniferous Series. They consist of red and yellow marls with bands of argillaceous limestone. In the quarry which Mr. Hardwicke is now working in the oolitic beds, the Basement Beds are freshly exposed. There is a blue argillaceous limestone (which, after treatment with acid, leaves a sandy residue) near the base, followed by red, yellow, and greenish blue marls, with bands of argillaceous limestone.

Beyond the Grovesend tunnel (Sub-section 5) the Basement Beds put on a wholly different character. They consist of a brecciated conglomerate, with pebbles of milky Quartz, derived from the Old Red conglomerate on which they rest, with occasional angular fragments of Mountain Limestone, the whole cemented in a red ferruginous and argillaceous limestone paste. The upper beds are less coarse than those below, but are of the same general character. Somewhat further on in the cutting these beds show well-marked striated slickensides.

At the $6\frac{1}{2}$-mile post yellow and reddish calcareous marls begin to be wedged in *between the brecciated beds*, the brecciated beds above containing larger limestone fragments and less milky quartz pebbles than those below. This wedge of marly strata thickens towards the foot-bridge; but within it is a band of argillaceous limestone, which thins out towards the bridge. Mr. Meredith's section does not show this arrangement of the Triassic beds.

The dovetailing of the marl with the brecciated beds is an exceedingly interesting feature. It was noticed and figured by Sir Henry De la Beche ("Survey Memoirs," vol. i., pp. 241, 242, 249), in the Mendips and elsewhere. But nowhere can it be seen more clearly than at the Thornbury end of the Tytherington section.

The Basement Beds of the Keuper in the Tytherington section show very clearly the variable nature of the deposit formed in the Keuper lake, under differing conditions in a gradually sinking area.

It should be noted that in Shillard's Lane, just to the west of the Tytherington district, at Alveston, and along the Mountain Limestone ridge leading to Almondsbury Hill, Lias is mapped by Mr. Sanders and the Survey as resting directly on the Palæozoic rocks. These beds there overlap the Trias. The Palæozoics on which they rest were dry land throughout the Keuper period.

5. *Modifications of the Map.*

The map published with this paper is based on and is on the same scale as Mr. Sanders' map, with some slight modifications in topographical details, introduced from the six-inch Survey map. When Mr. Sanders' map was printed, the Tytherington cutting had not been made; and the knowledge it gives us necessitates some changes in the boundaries of the strata.

(1) Carboniferous rocks (Upper Transition Beds) are proved in the field to the east of the Station, where Mr. Sanders marks Trias. I have therefore joined up the isolated patch of Carboniferous, which Mr. Sanders shows to the west of the Station, with the main mass of Tytherington Hill.

(2) The patch of Trias proved by the section to exist beyond the Tytherington Tunnel has been introduced, and has been connected provisionally with the Trias inlet to the west of Castle Hill. The contour of the ground seems to me to justify this.

(3) The outcrop of the Lower Transition Beds is proved by the section to lie, near Grovesend, somewhat further to the south than is indicated by Mr. Sanders; and the boundary of the Old Red Sandstone must also be be brought some distance further down in the same direction.

These modifications of the geological map will be clearly evident, if that which is published with this paper be compared with Sheet 4 of Mr. Sanders' admirable publication.

Since the foregoing was in type, I have found the Bryozoa Bed in the Mendips, in one of the lateral valleys of Burrington Combe. In Burrington Combe the Gully Oolite is also well represented.

NOTES SUPPLEMENTAL TO THE

Flora of the Bristol Coal-field.

1888.

By JAMES WALTER WHITE, F.L.S.

Papaver Argemone, *Linn.*

The two bristly-capsuled poppies are among our greater rarities; instances of the occurrence of either of them within the Bristol district being extremely few. In 1843 Mr. G. S. Gibson found *P. Argemone* near Uphill; and in 1878 a specimen was gathered by myself near Stapleton, whence the plant is recorded by Swete on the authority of Mr. H. O. Stephens and Mr. T. B. Flower. The connection of *P. hybridum* with our local flora depends entirely upon a statement communicated by the late Rev. J. C. Collins, of Bridgwater, to Mr. Hewett Watson, and which will be found in *New Bot. Guide*, *Suppl.* as follows:—"*Papaver hybridum.* Abundantly in fields at the mouth of the river Parret, at Steart and Burnham. *J. C. Collins*, *MSS.*" These poppies are colonists, inhabiting cornfields and waste ground, and their scarcity with us is very probably due to our lack of arable land. However, in June, 1888, I observed a colony of *P. Argemone* containing perhaps a hundred plants, some of them very large, growing near the railway at Patchway, G. In the same month Mr. D. Fry found a few on the shingle close to Brean Down, S., a few also on a bank at Berrow, and a much larger quantity in some neglected sandy fields nearer Burnham. One may be allowed to speculate upon the likelihood of this plant having grown as abundantly in the same locality sixty years ago. If it did, may not the Rev. J. C. Collins have mistaken it for *P. hybridum* when he made the record quoted above? No help can be got from Mr. Collins' specimens, as his herbarium, if he formed one, cannot now be found. In the absence of specimens, many of his Burnham and other records, which have never been confirmed by any other botanist, are open to grave doubt; and it is questionable if *P. hybridum* should still be included in our flora.

Lepidium Smithii, *Hooker.*

Mr. Harold S. Thompson has shown me a specimen, one of a small number that he observed in July, 1888, near Uphill, S. The plant is remarkably scarce in North Somerset.

Helianthemum polifolium, *Mill,* in North Somerset. Note communicated by Mr. David Fry.

As recorded in the "Journal of Botany" for October, 1888, this extremely rare plant was found, in the middle of last September, growing plentifully on Purn Hill, Bleadon, where its presence is noteworthy, as it has hitherto been regarded as exclusively confined in North Somerset to the southern slopes of Brean Down. Purn Hill is an elevation of the carboniferous limestone, situated inland to the S. E. of Brean Down, at a distance of about two miles from that promontory; and the abundant occurrence there of *H. polifolium* marks a somewhat important extension of its previously ascertained range in the vice-county of North Somerset. On the same hill several other interesting species, none of them very common in the district, were observed, amongst which may be named *Erodium moschatum*, *Trifolium scabrum*, *Spiranthes autumnalis*, and *Avena fatua*, *b. intermedia* (*Lindgr.*).

273* **Rubus pallidus,** *W. and N.* Reprinted from the "Journal of Botany," April, 1889, p. 118.

In face of so much uncertain nomenclature and varying opinion on the identity of British Rubi, I have refrained from furnishing supplemental notes on the brambles of the Bristol Coal-field since the publication of the "Flora," although some forms at that time not clearly understood have now been satisfactorily made out, two or three new species gathered and identified, and many additional localities recorded. An amount of general interest attaches, however, to one of these later discoveries, and it may not be premature to offer a few remarks on the occurrence of *R. pallidus* W. and N. in North Somerset, especially as I believe this species has only once been previously observed in Britain, namely, in Norfolk, by the Rev. E. F. Linton (see "Reports of the Botanical Exchange Club," 1885, 1886). The plant is strikingly handsome. On the barren shoot the leaflets are cordate acuminate thin, and almost glabrous on both sides, and have a peculiar crenate-dentate outline that I have never remarked upon any other bramble. It grows in great abundance on the marshy and wooded banks of a stream skirting Downside Common, Edford, about a dozen miles south-east of Bristol. The endeavour to ascertain if the plant had been already described gave a good deal of trouble. Two leading consults suggested that it might, perhaps, be a form of *R. scaber*, to which, undoubtedly, it is nearly allied. But the true *scaber* W. and N. (very little known in this country) has leaflets with fine and shallow serration, not crenate-dentate, as in this Edford plant. Later on, I learnt from Mr. Purchas that my specimens were just like some from Norfolk that Dr. Focke had named *pallidus*, and also that they corresponded well with pl. 29, "Rubi Germanici." On receiving examples from Sprowston, I saw that the puzzle was solved; and in a recent letter Mr. Linton informs me that he is quite satisfied that our plant is identical with his. That we should have in the west country a plant but recently observed for the first time in the extreme east of England is certainly remarkable. *R. pallidus* W. and N. will take a place among the British Rubi; and, as a welcome consequence, the term *pallidus*, as applied to a slight variety of *R. Koehleri*, should be relinquished. This bramble appears to have been mistaken for *R. humifusus* Weihe, and is recorded as such by Rev. R. P. Murray in his "Notes on Somerset Rubi," published in Journ. Bot., 1886.

Rubus saxatilis, *Linn.*

The Europæan flora contains five herbaceous Rubi that are in strong contrast to the fruticose section of the genus, for not one of the five possesses a synonym or named variety. Two only—the cloud berry and the subject of the present note—are to be found in Britain. *R. saxatilis* is very rare in the West of England, though frequent in the north and in Ireland. In Devonshire it was formerly known in two localities; but since 1837 the plant has apparently been present in but one. In Somersetshire we are acquainted with it at Asham Wood, near Frome, in the south-eastern corner of the Bristol district; and now Mr. H. S. Thompson produces specimens gathered in a rocky limestone wood, near Banwell Castle, a spot much nearer home.

404* **Valerianella carinata**, *Lois.*

An addition to the "Flora." Specimens from Hampton Down, near Bath, have been shown me by Mr. A. E. Burr.

Anthemis nobilis, *Linn.*

It must be admitted that this is one of a few species that were given places in the "Flora" on slender grounds. The consideration that an area so large as that of the Bristol district was very unlikely to turn out a blank in the distribution of certain plants was, in two or three cases, allowed to support a doubtful record or authority, which, in the absence of such consideration, would have been rejected. Events have fully justified this course in more than one instance, not the least satisfactory being that of the Chamomile, now reported with voucher specimens from Brean Down by Mr. H. S. Thompson.

526* **Symphytum tuberosum,** *Linn.*

Colonist. Well established in great abundance on an embankment near Montpellier Station, and pointed out to me by Mr. H. S. Thompson.

Leonurus cardiaca, *Linn.*, in North Somerset. Communicated by Mr. D. Fry.

This very rare plant appears to have grown formerly at several localities in the neighbourhood of Bristol, but had not been recently observed until 1881, when it was discovered near Lympsham, by Mr. T. F. Perkins (see "Flora," p. 141). It may be interesting now to record that it was also found abundantly last autumn (1888) in a lane near Burnham, where, though most likely not native, it has the semblance of a thoroughly established denizen, derived probably from ancient cultivation. It appears to be known to the country-people by the name of "Wild Stinging-nettle," a rather inappropriate designation, as the plant, though somewhat prickly from the bristles of the calyx-teeth and bracteoles, is entirely devoid of any strictly urticating properties. We were further informed that whilst donkeys eat the common nettles with which the *Leonurus* is growing, they carefully avoid the latter plant, not having yet learnt, it would seem, to appreciate the "cardiac" virtues attributed to it by the old herbalists.

674* **Polygonum maritimum**, *Linn.*

In addition to some other good things that are noted in this paper, Mr. H. S. Thompson has produced a specimen of the rarest British Polygonum, which he gathered on Burnham sands in July, 1882. At that time the discoverer was not sure of the species, and therefore did not recognise the importance of his find. But his specimen is undoubtedly the true plant. The presence of *P. maritimum* on the coast of Somersetshire has never been suspected, although the great range of sandhills between Brean and Burnham is similar, in some respects, to that at Braunton, the North Devon habitat for the species.

Euphorbia platyphyllos, *Linn.*

This uncommon Spurge has been recorded at various times for several localities in the Bristol Coal-field, but the only spot in the district at which it was certainly known to exist in 1883, when Part IV. of the "Flora" containing the Euphorbiaceæ was published, was a corn-field at Filton, Gloucestershire, where it had been noticed for several years in succession. Since then it has, for some time past, disappeared from that station, and it seems therefore worth noting that several plants of the species were found last autumn (1888) by Mr. D. Fry in corn-fields on Brent Knoll. Some of the specimens observed were particularly fine.

Salix triandra, *L.* var. *β.* S. Hoffmanniana, *Sm.*

Has been identified in two localities, both in North Somerset. It grows in a hedge near Berrow village, rather sparingly; and in greater quantity near a large pond, full of the white water-lily, about a mile from Brent Knoll. Pointed out to me by Mr. D. Fry.

Salix purpurea, *L.* var. δ S. Lambertiana, *Sm.*

Mr. D. Fry found this willow also, growing with or near to the other, in both the localities mentioned.

Scirpus Caricis, *Retz.*

This club-rush, which is, perhaps, better known under its synonym *Blysmus compressus*, Panz., was recorded on good authority many years ago for Stapleton, Gloucestershire, and for a spot in North Somerset, near Bath, both localities being within the area of the Bristol Coal-field; but its presence in the immediate neighbourhood of the Bristol Channel had never been made known until July, 1888, when it was discovered by Mrs. D. Fry growing abundantly in peaty ground near Burnham, in association with *Carex disticha*, Huds, and other paludal species. As this plant is now almost certainly extinct at Stapleton, and does not grow abundantly in the neighbourhood of Bath, its discovery at Burnham enables us to retain in our flora an interesting species which previously could hardly be regarded as permanently located in the Bristol district.

Cynosurus echinatus, *Linn.*

Alien. Five or six plants in St. Philip's Marsh, June 7, 1888. A native of the Channel Islands and southern Europe.

Molinia cœrulea, *Moench.*

Although not of uncommon occurrence on heaths and moorland throughout the kingdom, and perhaps not absent from any English county, this grass is little known in the vicinity of Bristol. Until last summer we supposed that it could not be found nearer than the Mendips in Somersetshire, or on Yate Common in the northern division of the district. *Molinia* is not mentioned in Swete's book, nor in any list of Bristol plants with which I am acquainted. But in the Stephens Herbarium there are specimens from "Durdham Down," not dated. Dr. Stephens was an accurate botanist, and his collection is excellent; but unluckily for those who are engaged in working out the distribution of Bristol plants, he very rarely attached to his specimens the locality and date of their collection. All that we knew, therefore, was that some thirty or forty years ago the "purple hair-grass" had been gathered on our downs, and had probably been extirpated since that time by some adverse influence. Consequently it was with some astonishment that last September I observed a large quantity of the plant flowering among the furze-bushes near the band-stand on Clifton Down, and also in another spot close to the fountain. The stems, being mostly a yard high, were noticeable at a distance, and, at the latter place, could be recognised from the road. Mr. Wheeler informs me that about the same time he likewise observed it on Durdham Down, near the Gully.

It cannot be deemed possible that the conspicuous panicles of *Molinia*, had they been regularly produced, season after season, could have escaped notice in spots so much frequented, and have been entirely overlooked by scores of botanists who have examined the locality of late years. Nor is it possible that the plant could be introduced in such abundance over so wide an area. To account for its resuscitation we must, I think, believe that this, like some other species, may be uncertain in flowering, and may require for its perfect development some unusual climatal conditions. That a very wet summer following the great heat of 1887 induced the plants, which formerly had flowered but sparingly or not at all, to produce a luxuriant crop, is, I think, a reasonable explanation of an extremely curious circumstance. There is little doubt that other plants were similarly affected. I observe that whereas last spring the trees of *Populus tremula* in Leigh Woods produced abundance of flowers, both barren and fertile, this year (1889) not a single catkin was to be seen upon them; and much the same thing has occurred with the Hornbeams in Clifton.

The Fungi of the Bristol District.

PART XI.

By CEDRIC BUCKNALL, Mus.Bac.

THE following species are, I believe, either hitherto unrecorded as British, or have occurred for the first time in Britain in this district:

1332. CORTINARIUS (TELAMONIA) NITROSUS, *Cooke, Grevillea, XVI., p. 44. Illus, pl. 837.*

*1333 CORTINARIUS (HYDROCYBE) BICOLOR, *Cooke, Grevillea, XVI., p. 45. Illus., pl. 820, f. B., and pl. 871. Cort. quadricolor, No. 1046 ante.*

1334. PAXILLUS (LEPISTA) LIVIDUS, *Cooke, Grevillea, XVI., p. 45. Illus., pl. 861.*

*1337. RUSSULA (FRAGILES) PULCHRALIS, *Britz, Grevillea, XVII., p. 41. Cke., Illus., pl. 1095. R. nitida, No. 1098 ante.*

1347. DACRYMYCES CÆSIUS, *Fr.* (?). *Hym. Eur., p. 699.*

*1359 PEZIZA LAPIDARIA, *Cooke, Phil. Brit. Disc., p. 211. P. hybrida, No. 1074 ante.*

For the many interesting species from Clevedon mentioned in the following list, I am indebted to Mr. R. Baker, and for those from Yatton to Mr. E. Wheeler, who has made beautiful and accurate drawings of a very large number of the Fungi of this district.

1322. Agaricus (Clitocybe) maximus, *Fr.*	Clevedon,	Sept., 1887.
1323. Agaricus (Collybia) maculatus, *A. & S.*	Leigh Woods,	Oct., ”
1324. Agaricus (Collybia) tenacellus, *Pers.*	Berwick Wood,	May, 1889.
1325. Agaricus (Pleurotus) Leightoni, *Berk.*	Yatton,	Dec., 1888.
1326. Agaricus (Pluteus) salicinus, *Pers. Fries. Hym. Eur. p. 186.*	Leigh Woods,	Oct., 1887.

This curious species has only once before been recorded as British, having occurred at South Wootton in the year 1882.

It is recorded by Messrs. Plowright and Phillips in "Grevillea," vol. XIII., p. 48. My plant grew on an old decayed tree trunk, probably oak; but the strange mixture of colours, cinereous, indigo, æruginous, dirty yellow, and pink, leave no doubt as to its being the same plant as that found on willow.

1327. Agaricus (Pholiota) adiposus, *Fr.*	Clevedon,	Oct., 1887.
1328. Agaricus (Hebeloma) glutinosus, *Lind.*	Blaise Castle Woods,	Oct., 1888.
1329. Agaricus (Inocybe) lanuginosus, *Bull.*	Leigh Woods,	Oct., 1887.
1330. Agaricus (Hypholoma) lacrymabundus, *Fr.*	”	Dec., 1888.
1331. Cortinarius (Phlegmacium) varius, *Fr.*	”	Oct., 1887.
* Cortinarius (Telamonia) laniger, *Fr. Cooke, Illustrations, pl.* 800, *No. 1263 ante.*	Abbott's Leigh,	Sept., 1885.
1332. Cortinarius (Telamonia) nitrosus, *Cke.*	Durdham Downs,	Sept., 1884.

"Stinking. Pileus, fleshy, rather thin, obtuse, convex, then expanded (2–3 inches), undulate at the margin, fawn-colour or tawny, darker and brownish at the disk, soon breaking up into minute, somewhat concentric darker scales. Stem short, stout, solid, ochraceous, darker at base, nearly equal (2–3 inches long, ½ inch thick), paler than the pileus, marked below with concentric, darker, squamose bands. Gills rather broad, somewhat distant, emarginate, violet, then watery cinnamon. Spores elliptical, 12 × 4 μ."—*Cke. in* "*Grevillea*," vol. XVI., p. 44. *Illus. t.* 837.

This has occurred more or less abundantly every year since its discovery in 1884, on the wooded slope to the south of the gully on Durdham Down, where also many other rare Cortinarii may be found; and I am not aware that it has yet been met with in any other locality. The colours in the above-quoted figure are scarcely bright enough, the gills being of a beautiful violet colour, and the stem white and floccose, with bright brown scales.

* Cortinarius (Telamonia) limonius, *Fr.* — Durdham Downs, Oct., 1883.

Cke., Illus., t. 804. Cort. percomis, No. 1038 ante.

1333. Cortinarius (Telamonia) injucundus, *Weinm.* — Brockley Coombe, Nov., 1886.

My plant corresponds fairly well with Dr. Cooke's figure, *Illus. t.* 823, but he remarks that this is not typical. My specimen is more umbonate, but it is difficult to refer it to any other species.

* Cortinarius (Hydrocybe) bicolor, *Cke.* — Blaise Castle Woods, Oct., 1882,

"Pileus rather fleshy, campanulate, then expanded, broadly, or occasionally rather acutely umbonate (1–2 inches diam.), somewhat fragile, dingy whitish, with an occasional tinge of lilac, even, smooth, silky, shining, flesh thin, colour of the pileus, or paler. Stem equal, or attenuated downwards (about 2 inches long, ¼ inch thick), pallid violet, becoming whitish, solid. Flesh bright purplish-violet at the base, pallid above. Gills adnate, with a tooth, sub-ventricose, slightly eroded at the edge, rather broad, scarcely crowded, purplish violet, then cinnamon. Spores elliptical, a little attenuated towards one or both ends, 10 × 5–6 μ. Veil fugacious, white."—*Grevillea*, vol. XVI., p. 45. *Cke., Illus. t.* 820, *f. B., and t.* 871. *Cort. quadricolor, No.* 1046 *ante.*

This species was met with abundantly at one of the Fungus Forays in the Forest of Dean, and was then found to differ considerably from the true *C. quadricolor*. Pl. 820 f.B. of the "Illustrations," taken from the Blaise Castle specimens, evidently belongs to the same species.

1334. Paxillus (Lepista) lividus, *Cke.*	Leigh Down,	Oct., 1882.

"Pileus convex, at length slightly depressed at the disk, dingy white or livid ochraceous, opaque (1–2 inches). Stem attenuated downwards, white (3–4 in. long, ½ in. thick), fibrillose, stuffed, then hollow. Gills arcuate, decurrent, white, almost crowded. Spores globose, nearly white, flesh nearly white." —*Grevillea*, vol. XVI., p. 45. *Illus. t.* 861.

1335. Russula (Furcatæ) sardonia, *Fr.*	Coombe Hill,	Oct., 1888.
* Russula (Furcatæ) purpurea, *Gillet, Cke. Illus. t. 1022.*	Coombe Dingle,	Aug., 1877.

This was referred doubtfully to *R. cyanoxantha*, at vol. ii., p. 212, but so nearly resembles the figure in the "Illustrations," that I have little hesitation in naming it as above.

1336. Russula (Heterophyllæ) cyanoxantha, *Fr.*	Hanham,	Oct., 1888.
1337. Russula (Fragiles) aurata, *Fr.*	Portishead Woods,	Aug., 1888.
* Russula (Fragiles) pulchralis, *Britz.*	Stapleton,	Sept., 1884.

"Pileus viscid, thin, convex, then flattened and depressed (2 inches diam.), circumference ochraceous, centre spotted with red or purple, margin thin, deeply striate, and often split. Stem equal, ventricose, or thickened at the base, fragile white. Gills broad, distant, rather thick, whitish, then ochraceous yellow. Spores nearly globose, 9 × 8 μ."—*Grevillea*, vol. XVII., p. 41. *Cke., Illus. t.* 1095. *R. nitida, No.* 1098 *ante.*

1338. Russula ochracea, *A. & S.*	Leigh Down,	July 27th, 1880.
1339. Boletus flavus, *With.*	Leigh Woods,	Oct., 1887.
1340. „ castaneus, *Bull.*	Blaise Castle Woods,	Sept., 1883.
1341. Polyporus perennis, *Fr.*	Clevedon, Leigh Woods, (Mr. L. Rogers),	Sept., 1887. May, 1889.
1342. „ lucidus, *Fr.*	Clevedon,	Oct., 1887.

1343. Polyporus igniarius, *Fr.*	Clevedon,	Oct., 1887.
1344. " Vaillantii, *Fr.*	Hanham,	" 1888.
1345. Clavaria lilacina, *Fr.*	Blaise Castle Woods,	" "

A beautiful species, exactly resembling Schaeffer's figure of *C. purpurea* to which Fries refers.

1346. Clavaria stricta, *Pers.*	Clevedon,	Sept., 1887.
1347. Dacrymyces cæsius, *Fr.* (?).	Leigh Woods,	Dec., 1888.

On a dead twig. Minute, roundish, convex, hyaline white. Sporophores globose, ·0005 inches diam. Spores subcylindrical, curved ·00055 × ·0002 inches, at length 1 septate (?).

1348. Lycoperdon giganteum, *Batsch.*	Clevedon,	Aug., 1888.
1349. Physarum Schumacheri, *Spr.*	Portishead Woods,	June, 1889.
1350. Didymium clavus, *A. & S.*	Yatton,	Dec., 1888.
1351. Trichia contorta, *Rost.*	Leigh Woods, Yatton,	Spring, 1881. Dec. 1888.

Plasmodiocarp creeping, flexuous, subcompressed, umber or bay-brown; mass of elaters and spores yellow; elaters $2{\cdot}5$–$3{\cdot}5\,\mu$, cylindrical, tips usually swollen and terminated by a long slender spine, there is sometimes an interstitial swelling; spirals indistinct; spores globose, minutely warted, 12–$15\,\mu$ diameter.—*Massee, Revision of the Trichiaceæ, Jour. Roy. Mic. Soc.*, 1889, *p.* 337. *Cooke. Myx. Brit. f.* 229.

1352. Hemiarcyria clavata, *Pers.*	Clevedon,	April, 1888.
1353. Puccinia vincæ, *B.* (Uredo spores).	"	May, 1889.
1354. Stilbum erythrocephalum, *Ditm.*	"	Oct., 1888.
1355. Volutella hyacinthorum, *Berk.*	Cotham, (A. Leipner, Esq.),	Mar., 1889.
1356. Tuberculina persicina, *Sacc. Syl. IV., No. 3088.*		

On *Æcidium Tussilaginis.*

1357. Peziza Adæ, *Sadler.* Bristol, Sept., 1888.

This beautiful and rare species occurred in great abundance on a wall against which chemical manure had been lying, and I am indebted to Mr. Waterfall for numerous specimens, which I have handed to the Rev. J. E. Vize for publication in his "Fungi Britannici." The only previously recorded localities appear to be a garden at Dalston, London, where a single specimen was found by Dr. Cooke, but not at that time described; and Inverleith House, Edinburgh, where it was discovered by Miss Ada Balfour, after whom it was named.

1358. Peziza cerea. *Sow.*

1359. ,, melaloma, *A. & S.* Leigh Woods, Oct., 1887.

This was extremely abundant on burnt ground in the inclosed part of Leigh Woods, forming large patches several yards in diameter, where the ground had been cleared and the undergrowth burnt.

* Peziza lapidaria, *Cke., Brit. Disc., p. 211.* Bristol, July, 1885.

This is the plant referred to by Dr. Cooke in "Grevillea," vol. XII., p. 43 (No. 1074 *ante*), as probably belonging to *Peziza hybrida*, Sowerby, to whose figure my specimens bear a great resemblance; but they do not sufficiently agree with his original specimen, which has since been discovered in the Kew Herbarium, and Dr. Cooke has therefore described it under the above name.

1360. Peziza (Lachnella) luzulina, *Phil. Brit. Disc., p. 244.* Black Rock Quarry, Jan., 1888.

1361. Ombrophila clavus, *A. & S.* Abbott's Leigh, June, 1887.

1362. Nectria punicea, *Schm.* Yatton, Dec., 1888.

A Few Notes on Heliothis Scutosa.

By W. KEMPSTER MANN.

Read before the Entom. Sect., Feb. 12th, 1889.

THE specimen exhibited is perhaps the rarest species of *Lepidoptera* that has ever been recorded from the Bristol district. It was captured by Mr. A. H. Jones, at Burnham, Somerset, August, 1877, flying at dusk over a species of clover. It passed into the collection of Mr. W. H. Grigg, and has now come into my possession with his collection.

This species appears to have been taken so far back as 1833, near Dalston, Carlisle, by Mr. James Cooper, who carried it alive to Mr. T. C. Heysham. It was forwarded to Mr. Curtis, who figured and described it in his "British Entomology," plate, 595. Another specimen was taken on the coast near Shinburness in August, 1834.

As far as I can find, it was not recorded again until Mr. Thornthwaite took one in the summer of 1875, and another in 1876, both in Norfolk.

Mr. C. G. Barrett, in recording the capture of these two, observed (*Ento. Mo. Mag.*, p. 281, vol. 13), they were the first genuine British specimens, and that the Carlisle species was *Dipsacea*; but in vol. 14, *Ento. Mo. Mag.*, p. 67, Mr.

Barrett admits sufficient evidence has been brought forward to convince him of the authenticity of *Scutosa* having been taken in Carlisle.

Another example is recorded in the *Ento. Mo. Mag.*, vol. 15, p. 137, by W. H. Campbell, who captured it August 19th, 1878, in the north of Co. Donegal, Ireland. It was hovering over the bloom of heather at 3.30 in the afternoon. I have heard of no recent captures.

On the Continent this species is very widely distributed, and is said to be double-brooded. It has been taken on the wing from May to September; and Professor Hering says: "Very uncertain in its appearance; rare in some years, whilst in others common." Thus the double-brooded theory has probably arisen from the uncertainty of its appearance in varied localities. It is well known that other species in the same genera are of most uncertain habits. For instance, I have taken *Heliothis Armiger* in July, flying in the hot sun, and another in September, flying round a gas lamp.

Mr. Thornthwaite's two specimens were taken by light, and Mr. Campbell's was flying in the hot sunshine.

This species is figured by Curtis and Wood, included in Stephen's Museum Catalogue of British Lepidoptera, and described in Stainton's Manual; Doubleday places it amongst the reputed British species; Newman omits it entirely.

Kirby describes it as having the fore wings dark olive-grey, varied with white in the central area, and with whitish nervures; the three stigmata very large, dark brown, the subterminal line whitish, hind wing dirty white with a large brown central spot and border, the latter intersected by a pale line near the inside, in addition to the pale spot towards the anal angle. The palpi are rather conspicuously porrected, the antennæ are simple in both sexes. The species varies slightly in the intensity of its colouring, and in the marginal band of the hind wings. Expands from 1¼ inch to 1½ inch.

The caterpillar has been figured by Hubner, and described by Fruger and Treitschke. It is yellowish green, with the dorsal and subdorsal lines blackish; its whole surface is covered with small black dots and fine blackish streaks, with many black hairs proceeding from each dot, which form, as it were, small tufts. The head reddish brown spotted with black; it also varies to green at the sides, the ground colour being grey. These are divided by a lateral stripe. The larva feeds on the Field Mugwort, *Artemsia campestris*, in July and August.

The pupa is slender, reddish brown and greenish on the wing-cases, and is enclosed in a slight and loose cocoon, either under the earth or amongst its food plant.

I have omitted to state that the larva also feeds on the common Mugwort, *Artemsia vulgaris.* The larva has not yet been found in the United Kingdom.

Rainfall at Clifton in 1888.

By GEORGE F. BURDER, M.D., F.R. Met. Soc.

TABLE OF RAINFALL.

	1888.	Average of 35 years.	Departure from Average.	Greatest Fall in 24 Hours.		Number of Days on which ·01 in. or more fell.
				Depth.	Date.	
	Inches.	Inches.	Inches.	Inches.		
January . .	1·110	3·320	−2·210	0·470	2nd	8
February .	1·737	2·293	−0·556	1·345	13th	9
March . .	3·541	2·186	+1·355	0·553	8th	17
April . . .	1·775	2·079	−0·304	0·393	19th	15
May . . .	1·405	2·434	−1·029	0·471	17th	8
June . . .	3·998	2·555	+1·443	1·130	21st	16
July . . .	6·225	2·911	+3·314	0·716	16th	25
August . .	2·547	3·451	−0·904	0·580	28th	16
September .	1·284	3·373	−2·089	0·250	5th	9
October . .	1·063	3·724	−2·661	0·301	28th	11
November .	6·530	3·017	+3·513	1·535	12th	25
December .	3·294	2·881	+0·413	0·582	27th	15
Year . . .	34·509	34·224	+0·285	1·535	Nov. 12th	174

Remarks.—The rainfall of 1888, although differing but little from the average as regards the total amount, presented some remarkable features as regards its distribution in the several months. July and November were excessively rainy months. March and June were also rainy, in a less degree. January and May were specially dry months, as were also the three consecutive months of August, September, and October. October was the driest month of the year, with a little over one inch of rain. November was the wettest month of the year, with six and a half inches. A very dry term extended from September 8 to October 27, when barely three-quarters of an inch of rain was collected in fifty days.

The very irregular distribution of the rainfall of the year will be apparent in the following series of comparisons of the falls in certain months and groups of months with the falls recorded in the same periods during the previous thirty-five years.

1. The fall in July (6·225 inches) is the largest recorded in that month.
2. The fall in June and July (10·223 inches) is the largest recorded in those two months.
3. The fall in November (6·530 inches) is the largest recorded in that month.
4. The fall in October (1·063 inch) is the smallest recorded in that month.
5. The fall in September and October (2·347 inches) is the smallest recorded in those two months.
6. The fall in August, September, and October (4·894 inches) is the smallest recorded in those three months.

A great snowstorm occurred on the 14th of February, the snow lying on the ground to an average depth of twelve inches, and drifting, under the influence of a northerly gale, to a depth, in places, of three feet or more.

Observations of Temperature at Clifton College, 1888.

By D. RINTOUL, M.A., Cantab.

THE following tables are compiled from the Meteorological Observations taken daily at Clifton College during the year 1888. In the series of observations there was a gap of ten days in April, but by the kindness of Dr. Burder I have been enabled to make the series complete.

It will be seen that the mean temperature for the year is somewhat lower than the average of the last eight years. Considering the monthly temperatures, we notice that January, February, March, June, July and August were colder than usual; the difference in February and July being especially noteworthy. November and December were considerably warmer than usual.

1888 TEMPERATURES.

MONTH.	Maximum in Shade.		Minimum in Shade.		Mean in Shade.	Minimum on Ground, Lowest recorded.
	Highest recorded.	Mean.	Lowest recorded.	Mean.		
January	53·3	42·30	22·3	34·96	38·54	18·6
February	53·1	40·68	22·3	31·44	36·06	18·0
March	58·0	44·00	24·0	33·30	38·65	18·0
April	60·0	50·48	28·7	37·72	44·10	24·8
May	70·5	60·22	35·2	44·81	52·51	34·8
June	73·6	65·53	43·7	50·23	57·88	41·0
July	69·5	63·95	41·4	52·85	58·40	38·6
August	79·1	65·89	46·5	52·71	59·30	42·2
September	69·8	62·07	41·4	52·50	57·28	38·9
October	63·0	57·20	32·3	40·48	48·84	28·0
November	58·3	50·66	34·0	43·72	47·19	30·0
December	57·3	47·27	27·5	38·20	42·70	23·8
Year 1888.	79·1	54·19	22·3	42·74	48·45	18·0
Year 1887.	82·8	56·0	20·4	40·9	48·4	11·7
Year 1886.	83·5	54·90	21·7	43·17	49·03	15·3
Year 1885.	87·8	53·98	22·1	42·53	48·09	20·1
Year 1884.	87·5	57·44	22·6	44·07	50·66	23·7
Year 1883.	82·5	54·54	20·9	42·88	48·71	19·3
Year 1882.	78·5	55·46	21·9	43·62	49·54	20·6
Year 1881.	86·9	55·44	12·3	42·92	49·18	5·8

MONTH.	Number of Days on which the Minimum Ground Temperature was below 32°F.	Number of Days on which the Minimum Air Temperature was below 32°F.	Number of Days on which the Maximum Air Temperature was below 32°F.	Number of Days on which the Mean Air Temperature was below 32°F.
January . .	17	14	1	8
February . .	23	20	1	8
March . . .	19	13	0	0
April . . .	12	6	0	0
May . . .	0	0	0	0
June . . .	0	0	0	0
July . . .	0	0	0	0
August . .	0	0	0	0
September .	0	0	0	0
October . .	7	0	0	0
November .	1	0	0	0
December .	14	7	0	0
Year 1888 .	93	60	2	16

Year 1887 .	148	63	2	11
Year 1886 .	102	64	1	22
Year 1885 .	68	40	1	6
Year 1884 .	51	19	0	1
Year 1883 .	79	40	0	6
Year 1882 .	63	26	2	7
Year 1881 .	94	60	11	24

MEAN SHADE TEMPERATURES OF THE MONTHS.

MONTH.	1881.	1882.	1883.	1884.	18 5.	1886.	1887.	1888.	Mean of Eight Years.
January . .	31·8	40·7	42·3	44·2	38·7	35·5	41·5	38·5	39·15
February .	39·3	42·6	43·3	42·3	44·0	35·8	41·0	36·1	40·55
March . .	43·0	45·7	37·0	44·9	41·7	40·1	39·9	38·6	41·36
April . . .	47·3	48·8	47·5	45·1	46·7	46·4	42·2	44·1	43·51
May . . .	54·4	53·7	49·9	53·3	47·0	52·2	45·5	52·5	51·13
June . . .	56·9	56·0	57·2	59·8	58·4	58·8	62·4	57·9	58·42
July . . .	65·9	59·6	57·2	60·7	62·6	62·7	63·9	58·4	61·37
August . .	58·8	60·2	60·6	64·5	57·5	59·1	60·4	59·3	60·05
September .	56·6	53·9	55·3	59·4	54·5	58·2	53·7	57·3	56·11
October . .	46·5	50·2	49·6	48·9	45·6	52·9	46·1	48·8	48·58
November .	48·3	43·7	42·8	41·6	43·3	47·1	41·2	47·2	44·39
December .	40·8	39·8	41·4	43·1	38·8	38·6	39·9	42·7	40·63
The Year .	49·2	49·5	48·7	50·7	48·1	49·0	48·4	48·45	49·00

"Trigonocephalus Lanceolatus."

NOTES ON THE WEST INDIAN "FER-DE-LANCE."

DR. WILLIAM DUNCAN.

Read February 7th, 1889.

THE Fer-de-lance belongs to the family *Crotalidæ*, or Pit Vipers, of which perhaps the best known member is the Rattlesnake. The *Crotalidæ* are distinguished from the true vipers (*Viperidæ*) by a pit in the loreal region between the nostrils and the eye. These two families constitute the sub-order *Ophidii Viperiformes*, the fourth of the four sub-orders into which the snakes or ophidii are divided by modern zoologists. They are characterized by the triangular head and short tail and by the very short maxillary, or upper jaw bone, which bears a single long perforate poison fang (although there may be several reserve fangs). The maxillary is capable of rotation on its transverse axis, and this rotation causes the erection of the tooth when the mouth is wide agape. Small hooked, solid teeth are present in the lower jaw and palate.

The Fer-de-lance belongs to the genus *Trigonocephalus* (*Craspedocephalus* of some authors) of which there are three species, *T. jararaca* and *T. atrox*, which are common in Brazil, Central America, and Jamaica, and *T. lanceolatus* (the Fer-de-lance itself), which is limited to the West Indian islands of Martinique and St. Lucia. The Bushmaster (*Lachesis mutus*) of Demerara and the hottest parts of tropical America is a cousin of the Fer-de-lance, exceeding it in size, and being probably the largest of terrestrial poisonous snakes (up to ten feet).

The Fer-de-lance is a very beautiful snake, of an olive-green hue, with dark cross-bands, and greyish-white below, studded with black dots. The head is brown and large, and triangular in shape, like the head of a lance; hence the name. They are usually seen from three up to eight feet long, and are often from six to ten inches or more in circumference. Very extravagant accounts are given by the Rev. J. G. Wood and others of the ferocity of the Fer-de-lance. It is said that horses will not pass anywhere within striking distance of the serpent, and neither spur nor whip can avail if there is one in the way; that he will always take the initiative in attacking his prey, and that no animal, however large, is safe from his terrible fangs. Wood says "that the pig, *when in good condition*, is said to be the only animal that can resist his poison, the thick coating of fat which covers the body preventing the poison from mingling with the blood." But pigs in St. Lucia have never been known to be "*in good condition*," and whether *post hoc* or *propter hoc*, the fact is that pigs *are* frequently killed by the Fer-de-lance, and probably in larger proportions than any other animal.

All who know the Fer-de-lance agree in saying that if anything he is rather a cowardly animal, and at least that he is no worse than other snakes that will only attack in self-defence or when their retreat is cut off. The manner in which he strikes at his prey is peculiar. The poison fangs are long, hollow, slightly curved tubes, with the poison gland at the root, and the duct terminating from $\frac{1}{16}$ to $\frac{1}{4}$ of an inch from the point. They vary in length from $\frac{1}{2}$ an inch to $2\frac{1}{2}$ inches, and are very fine and brittle. When at rest they lie flat against the upper jawbones with the points directed backwards towards the throat. When an attack is intended, the mouth is opened to the fullest extent, till the jaws are in a line with each other, and the fangs are erected at right angles to the jaws, and by a sudden spring are driven into the victim. This sudden spring, however—at least in the Fer-de-lance—can only be made when the animal is in a particular position. He requires a firm foundation to stand upon, and to obtain this coils himself suddenly into a concentric circle, with his head in the centre; then using the outer coil of his body as a broad vantage ground to stand upon, he throws his head and the inner coils forwards and buries his fangs in his prey. This manner of springing has been invariably noted by observers in St. Lucia, and I have no reason to doubt the truth of the description.

From this it will be seen that the Fer-de-lance can only spring when he has plenty of tail to stand on, and as he must rest on it, he can only throw forward about two-thirds of his body, and the depth to which his fangs enter his victim is in proportion to the distance of his leap. He may bite at a person walking across the road, but he cannot make his poison fangs enter the flesh except under the conditions I have named. The average length of the snake is six feet; he cannot therefore injure any one at a greater distance than four feet. A man on horseback is therefore tolerably safe; so also it is safe to go under trees, even if a Fer-de-lance is lying in wait for you: he has no prehensile tail, and has no foundation on a tree for a circular coil of his body to rest on.

The fangs of the *Trigonocephalus* are extremely fine and brittle, so much so, that sometimes they break off short in the wound, and very often have to be drawn out or cut out of the flesh. The negroes say that after a snake has spent its energy in biting a person he dies; but there can be no doubt that, as in other *Viperformes*, when a poison fang is broken, one of the reserve fangs becomes attached to the maxilla, and is soon functional.

At my first interview with the colonial surgeon of St. Lucia, my friend Dr. C. Dennehy, I asked him if the snakes were as bad as represented; and he laughed the idea to scorn, showing me at the same time a bundle of serpent fangs, about twenty in number, and remarking that they were good for vaccinating negro children, but the points of most of them were injured; he also suggested that with a little manipulation they could be made useful as hypodermic needles in case of need.

The negroes of these islands have no fear of the Fer-de-lance if they possess a small walking-stick. He is very easily killed, for the lightest tap dislocates the vertebral column and renders him incapable of leaping. So little fear indeed have they of him, that when, about fourteen years ago, the then governor of St. Lucia offered a reward of 4*d*. for every serpent's head, many negroes caught them alive and bred young families of snakes for the sake of the reward, and thereby made moderate fortunes. Needless to say, the reward had to be abolished very soon, for serpents are extraordinarily prolific, bringing forth seldom less than 100, and often as many as 200 at a birth. The female Fer-de-lance has not the credit of being particularly fond of her offspring, and her behaviour to them in their helpless infancy is worthy of record. She generally selects a fairly open or cleared space for her lying-in chamber, a mountain footpath being her favourite spot. Along this she crawls slowly, dropping her young one by one on the way. As soon as the last has been brought forth, the faint and hungry mother turns in her onward stride and devours the first of her brood that meets her sight, and continues this unnatural course until satiated with her repast, or she finds no more of her offspring wherewith to glut her rapacity. Naturally many of them, three-fourths at least, escape, and these the strongest,—a clear case of the survival of the fittest. This has been observed by several planters in St. Lucia, and has been mentioned to me independently by Mr. E. S. Gordon, Mr. A. R. Marucheau, and Mr. Marius Devaux, and others of the colony.

Since the Government reward alluded to proved a failure, it remained a subject for private enterprise how best to rid the colonies of St. Lucia and Martinique of so formidable a pest. An attempt was made about 1870 by Mr. John Goodman, of Pointe Sable Estate, to introduce into the island a species of frog which had been found useful in India, as supplying a poisonous food for poisonous snakes. At infinite trouble and expense he had about a dozen couples imported to St. Lucia, where he located them in a large pond close to his house, carefully guarding and feeding them. These multiplied to an alarming extent, but the experiment can never prove very successful, inasmuch as the frog is contented with the marshy pools and ponds of the valley, finding there abundant material for food, while the Fer-de-lance retreats to the mountain tops, where it can remain unmolested. Later still the mongoose has been introduced by the Government, at the initiation of Sir Roger Goldsworthy, but with what result I have not heard. Yet the Fer-de-lance has one formidable enemy. This is another snake called the Cribo, the *Spilotes variabilis*. The two never meet without an encounter, in which the Cribo is invariably the victor. It is a pretty little creature, perfectly harmless, as all the other snakes in St. Lucia are, and is much petted and encouraged by the white population, as a guard and protection from its deadly rival.

Shortly after my arrival in the colony, I saw a *Spilotes* crawling lazily along the street near my own door, and burning with the desire to possess a Fer-de-lance of my own capture, I sallied forth armed with a broom stick and despatched the, to me, dreaded invader. Speedily a small crowd collected, anxious to see what I had done ; and I leave my readers to imagine my disgust at finding the negroes pitying my crass ignorance in slaying their best friend the Cribo. "Ah, mossoo," I heard one say, "you have to give account one day for taking dat life ; you gwine be *too* sorry you done dis ting." I never killed another.

A fight between a Cribo and a Fer-de-lance is an interesting sight. The poison of the latter seems innocuous to its rival, who, relying on his powerful muscles and jaws, pins his adversary by the neck, and twisting his body suddenly round him strangles him after a fierce struggle, and proceeds to eat him, beginning with the head. On one occasion a gentleman I knew witnessed one of these encounters ; and when the Fer-de-lance was half swallowed, he killed the Cribo, and had them mounted as they died. The Spilotes in this case was 4½ feet long, and the Fer-de-lance 1 foot longer, and half of the latter was in the stomach of the former.

I never had but one experience of close contact with a Fer-de-lance. I was riding with a friend across the Barra-Barra, a high mountain of about 4,000 feet in the interior of the colony. We had been climbing for about two hours from the leeward side of the island, and after resting our horses and having lunch in a shady place about 3,600 feet above the sea, had commenced our descent by an extraordinary zig-zag path on the windward side, when we were compelled to halt to admire a view, the grandeur of which is unsurpassed. At our feet lay a magnificent, undulating plain, twenty miles broad and half as many long, studded with huge forest trees and clad in all the gorgeous verdure of the tropics. Down one side of the mountain ridge was the zig-zag road made by the French government before our queen's father captured the island, and from our position it looked like a long ladder, down the steps of which it would be comparatively easy to jump. The exquisitely blue waters of the Caribbean Sea, the lovely green islands of Martinique and Dominica in the distance, all combined, made up a picture which it would take no mean artist to portray; but in the middle of our reverie on the beauties of nature in the tropics, we were suddenly recalled to a sense of the present by our negro servant in our rear calling out in French, "Prenez garde, Messieurs! Serpent! serpent!" My companion wheeled his horse round and struck with his long riding whip at the venomous reptile that, having been alarmed by the negro, was making towards us in all haste. The lash merely irritated it, and it bit furiously; but not having coiled itself for the spring, it was rather helpless, and so we lashed it until our faithful attendant had time to procure a good thick stick, with which he ended the conflict. It was only a small one, 3½ feet long, and with fangs about an inch in length. Similar experiences make travellers wary, and they seldom go on lonely roads unattended.

And now comes the inquiry, How is it that the venomous Fer-de-lance, with its French name, exists only in the colonies of Martinique and St. Lucia, and in none of the adjacent islands? Various are the reports accounting for their origin. Some assert that the aboriginal Caribs introduced them from the mainland of South America, to drive out the white usurper of their country. But Venezuela is 800 miles distant, a long journey to take snakes in such frail barks as the Caribs use. Again, some think they came on drift-wood from Guiana; but the strong current of the Orinoco would have washed them hundreds of miles eastward of St. Lucia into the centre of the Atlantic; and if this view were correct, why are they not to be found in Barbadoes, which lies almost in the current of the Orinoco? Again, some think that the French introduced them during their war-like relations with the English at the latter end of the last century, when these very islands were the scenes of so much bloodshed and strife, both nations alike coveting St. Lucia and Martinique, not only on account of their unsurpassed beauty and great wealth, with their forests of the finest wood for ship building and their mines of sulphur and alum, but coveted still more for their magnificent harbours and anchorage and almost impregnable fortresses.

I rather incline myself to the opinion that they are indigenous to these islands, and were so named by the French, who first discovered and described them. In whatever way they arrived originally, they are but too common now, and are perhaps most frequently found in the neighbourhood of the Pitons or Sugar-loaf Mountains.

These are two huge obelisks of granite rock, the one about two miles, the other about four miles in circumference at the base, and towering from the edge of the sea to a height of nearly 4,000 feet above its level. One of these Pitons is fairly accessible, the other has only been ascended by one man. There is an old story that a British crew once set out for the top of the smaller Piton, but were all killed by snakes, with one exception, before reaching the summit. This one reached the point, and had time to wave the Union Jack aloft, when he too was severely bitten, and died there.

In 1878, however, one man scaled this dreadful Sugar-loaf; but on his return he found so few to credit his story, that the day following he made the ascent a second time, taking with him a negro servant part of the way. He reached the point and lighted a fire, stuck up the Union Jack as a proof of his victory, and for six months it waved in the breeze, no one daring afterwards to disbelieve his veracity. He told me that on his way up he came to a high ledge which he could only reach by mounting on his companion's shoulders, and then drawing himself up by his hands and elbows. When he had his elbows on the ledge and brought his face to a level high enough to see over them, he was rather alarmed at seeing a huge Fer-de-lance lying in wait, within a few inches of his nose. He called for a cutlass, which his servant handed him; but by this time the reptile had coiled itself ready for a spring, and was just about to strike when the cutlass descended and cut it into several pieces. The brave fellow put the head in his pocket and went on his way. I saw the fangs, which were about 2¼ inches long, and on that journey alone he killed sixteen snakes.

Only on one other occasion have I heard of equal presence of mind with a Fer-de-lance. This was in a Barbadian negro, one of the most powerful and courageous fellows I ever met. He, with some other labourers, was cutting sugar-canes in a field apart from the rest, when suddenly the cry of "Serpent!" rang out, and looking at his feet, close beside him he saw a Fer-de-lance, over six feet long, coiled ready for the fight. He was unarmed and lightly clad, and recognised at once the fact that his only chance of safety lay in getting nearer the head of the snake, so as to diminish the impetus of the stroke. He threw therefore his naked body flat on the coiled snake, and succeeded in getting his hands round its neck; he held it as in a vice, then straightening its long body out with the other hand, he made it run the gauntlet of his powerful jaws, and in a short time it was dead. Negroes are not often hysterical, but after such a meal it can hardly be wondered that the poor fellow fainted.

As to the effects of the poison of the Fer-de-lance, there are various accounts, but from my own experience I should say the following are the most prominent symptoms. There is but little pain or swelling at the seat of injury, except in very bad cases, nor is there sickness or nausea. The injured limb first and then the body gets cold and insensible, and the pulse very weak and thready and respiration slower. Faintness increases, and brings on ringing in the ears and an inclination to sleep and dimness of vision, and sometimes there is contraction of the pupils. The poison acts chiefly on the heart, and as it gets weaker there is an increased dread of death, which when it comes is painless. On one occasion I saw a negro who, having been badly bitten in the hand, and there being no help near, had tied a ligature round his arm and completely cut off the circulation. Gangrene almost immediately developed, and in two days not a vestige of flesh remained on his arm from the shoulder downwards, so rapidly did it spread. I attempted to save his life by an amputation, but it was too late.

The only treatment of the slightest avail is to make the patient intoxicated as fast as possible, and his chances of recovery are in exact ratio to the amount of intoxication that can be produced in a given time. The native "panseurs," or medicine men, have a variety of "nostrums" by which they profess to cure serpent bite; but I believe they nearly all consist of rum in which cockroaches, scorpions, centipedes, and such like have been steeped for some time. My old friend Mr. Joseph de Laubenque, of the Malgretout Estate, near Soufrière, an estate close to the Pitons, and much infested with snakes, has for many years had an enormous reputation as a curer of snake bite. His treatment, which has been officially published by the Protector of Immigrants, has saved many a life; in fact, when taken in time, has invariably been found successful. It is simply twenty to thirty drops of the strongest solution of ammonia, one dram of theriaque, and a wineglassful of claret, every hour. This is accompanied by several soothing applications to the wound, and a liberal exhibition of any other stimulant that can be had.

Mr. T. H. Dix, one of the magistrates of the colony, on one occasion called my attention to a plant which had the reputation of keeping the Fer-de-lance at a distance. It was very like woodsorrel in appearance, but its name I forget. Mr. Dix had followed the example of others, and planted it round his house for use as a serpent fence, and he also told me that a tincture made from its leaves was used by many of the panseurs as an antidote.*

In conclusion, I will mention an incident of which I was personally a witness, to show the amount of liquor that may be imbibed with impunity in cases of serpent poisoning, and which proves how virulent must be the poison which can bear such an amount of antidote. A coolie was brought to my hospital on one occasion, from an estate about twelve miles distant, and on the way had imbibed over a quart of strongest rum in the space of about four hours. There was nothing in his appearance suggestive of anything but intoxication, and I determined to persist in the treatment already begun, and with my own hand I administered a pound of aromatic spirits of ammonia within the next twenty-four hours. Having no more at hand, but thinking that sufficient, I left him to his fate, and after some twelve hours more he recovered. When he had been told of his danger, and of our efforts to revive him, and especially of the quantity of liquor he had imbibed, he rubbed his stomach, and grinning from ear to ear, said: "All right, Doctor Sahib; dat serpent make um feel good *and thirsty*. Tell him come bite again; I no stop um."

---

* I am glad to have this opportunity of recording my obligations both to Mr. de Laubenque and Mr. Dix, not only for much useful information in natural history, but also for their great kindness and hospitality to me on many pleasant occasions. My intercourse with both these gentlemen was the happiest part of my West Indian experience.

Talpa; or, Remarks on the Habits of the Mole.

BY C. I. TRUSTED.

Read December 6th, 1888.

"'Genus *Talpa*.—Mole. Back covered with hair, furnished with a tail. Incisors in the upper jaw, six; in the lower, eight. No external ears. The sternum is furnished with a mesial crest. Fore feet broad and formed for digging.

"*Talpa Europæa*.—The fur of this well-known animal is usually black, but it is occasionally found in all the intermediate stages to yellowish white."

THE above is the concise description of this little creature given by Fleming in his "History of British Animals," to which I may add: The anterior members very short and strong, and large hands, turned outwards in such a manner as to permit the animal to throw the soil to the surface on right and left. The head succeeds the body without attenuation, thus being almost cylindrical. The nose is used for boring in the earth. The body is covered with fine, silky, short black hair. The eyes are hidden; they are small and black, and can be retracted and exserted at will, and they are said to protrude themselves when the Mole is in the water. The sense of hearing in the Mole is very acute, as also that of the olfactory organs. The number of teeth is said to be 44. Moles make long galleries in the earth, through which they can run swiftly. Their food is insects and earthworms. Only a single species occurs in Britain. Woods are their favourite breeding-places, and the large molehill they form at such times is not quickly discovered in the briars or underwood. I have found their nests with about five young moles, on the highest part of the bank of a hedge-row, and in such a situation as to be out of flood's way. When there is a nest underneath, the molehill above is a large dome, several times the ordinary size. There are many runs made, which radiate from the nest in all directions, with many galleries and passages. The nests are composed of dry leaves. I have not found any of dried grass or moss. When about half-grown the young moles appear to be almost naked, and all body, and make no attempt to escape: very odd-looking little animals, flesh-coloured cylinders you would incline to call them.

On reference to my Diary, I believe that December 20th, 1852, was the date when the churchwarden of the parish I then lived in, brought forward for the last time, at a parish meeting, his usual charge for paying the molecatcher. Many of the ratepayers considered they had no benefit from the arrangement, and so the charge was disallowed. However, this old custom had some claim for itself, as you will understand when I explain the injury caused by the Moles.

The river Wye bounded the parish on one side for a considerable way, and owing to the frequent floods in winter time, a high bank, or stank, as it was called (very similar to the one which you know extends from Avonmouth to the New Passage), extended, as a protection, about the breadth of a wide meadow from the river side. Now *Talpa* swims well; and in time of flood, although many may be drowned, yet I have seen the moles swim to this high bank, which was to them very safe and secure anchorage. If they had done no injury when there,- there would have been little cause for complaint, as far as the stank was concerned; but the Moles made their runs right through it, and so allowed the water to gush out on the opposite side into a deep pool, and close by this was a house and extensive farm premises. Owing to frequent floods these holes or runs in the bank increased in size, and in the high flood of February 6th, 1852, several yards of the embankment were suddenly carried away, about midnight, and in a few moments a part of the house, and the farm-yards adjoining it, were deluged with water. The cattle were fortunately saved from drowning, but great injury was done to the corn ricks and the contents of the barns, and in many other ways. The turnpike road adjacent was also rendered impassable, much to the inconvenience of the neighbourhood, and all travellers. So you see, *small* creatures may do *great* mischief!

Moles prefer some depth of soil for their hunting ground. I have never seen a mole hill on our Downs; yet probably a stray mole may come, now and then, to the north-east end. But I have known on the Downs two colonies of the *Arvicola Agrestis*, or Meadow Mouse; and, standing motionless, have watched their graceful and innocent ways whilst nibbling the blades of grass. On the least movement they would run away, down their narrow well-worn path, to their holes. In the course of my walks I chanced to see a Weasel near their runs, and on making a peculiar sound with my lips this active animal would come close to my feet. A few days afterwards, however, all my little friends the Meadow Mice were gone—doubtless fallen a prey to their enemy, the Weasel. I seem to remember a mole-catcher having told me that he had caught a Weasel in a trap set for the Mole, but think it is not conclusive evidence that the Stoat or Weasel kill and devour Moles: their flesh gives a repugnant odour.

The Rev. J. G. Wood, in his "Illustrated Natural History," says, "The Weasel is said to kill and eat Moles; and this idea is strengthened by the fact that Weasels have more than once been captured in Mole traps. These unfortunate animals were evidently snared in the act of traversing the same passages as the Mole, but whether their object was the slaughter of the original excavators is not clearly ascertained."

The traps used for the destruction of Moles are of three or four different kinds. The most common are the usual steel traps, with two handles and serrated prongs, kept apart by a plate, and the springe fixed in the ground and bent at one end, so often seen in the country. Another kind is a deep box, which is placed in a hedgerow, or bank, after it has been cut away transversely to a sufficient depth; and fixing this pitlike box underneath, the main run is then connected by a wooden trapdoor, through which the animal is obliged to pass, and thus falls into the box below, and must die a cruel death.

There is one point to which I would draw your attention; it is the intuitive knowledge possessed by the Mole respecting the changes of weather. It is intuitive, as it has not the power of reasoning. I have frequently noticed the afternoons previous to a hard frost, and again at the beginning of a thaw, that the Moles are very active, and are busily throwing up the earth. Probably it is because at those times the worms and insects begin to be in motion, and approach the surface; on the contrary, in very dry weather few mole-hills are to be seen, as the animal has then to go deep in the earth after its food. Hillocks rise up in all directions in the meadows where Moles abound, when there is likely to be a change of weather. It was my lot, at one time, to own and occupy a little property, bounded on the north by very extensive woods, where Moles were numerous. If they had been satisfied to remain in these woods they would have been harmless; but they migrated down into the cornfields and meadows, where there was a good depth of soil, and therefore their favourite hunting-ground. I have mentioned how active these creatures are when there is a prospect of change of weather, and I have a note in my diary that on January 26th, 1858, I shot nine Moles. I recollect that once also I shot eleven Moles in one day. My neighbours, who were great sportsmen, were very incredulous about my shooting them. Great caution is required, in order to approach with noiseless steps to the molehill, as the hearing of the animals is so very acute; and it is useless to shoot unless at the moment the earth is seen to rise.

Moles spoil much grass, and are mischievous in mowing grass. They are also injurious to agriculture, because they dig amongst the cultivated plants, raising up the young wheat and barley after it is sprouted; and although they do not feed on the roots of vegetables, yet they cut them in making runs and passages. Mole-hills are also very unsightly.

When returning from Dingle to Tralee, in Ireland, last year, my fellow-traveller, who belonged to the latter town, was a gentleman who had a taste for natural history, and amongst other things said that there were no Moles in Ireland. Although I had travelled so often and so much in

Ireland, this fact had not previously occurred to me. It is true I had never seen a molehill there. Since then I have searched all the books I possess on natural history, and only two authors notice the absence of Moles in Ireland. Pennant says, "We have been assured that Moles are not found in Ireland." "The Naturalist's Library on British Quadrupeds" says, "The Mole is said not to occur in any part of Ireland, or in Orkney, or Shetland. It is not met with in any of the Hebrides, excepting Bute, and is unknown in many of the northern and western districts of the Highlands; but is distributed over all the other parts of Britain, from the level of the sea to the height in some places of a thousand feet or more, although more abundant in the lower or richer ground." I have lately inquired of an acquaintance at Belfast, who is a good and observant naturalist. He says, "It *is* a fact that Moles do not exist in Ireland." This is remarkable, as a large portion of the South and East, and part of the North of Ireland appears well suited to the habits of the Mole. Much of Connaught may be too wet, and other parts of it too denuded of soil.

If we examine the structure of this animal, we shall notice the wonderful adaptation, and how well suited in form for its peculiar habits and mode of life. I have no means of ascertaining to what age it may attain, but as the food it feeds on is so plentiful, and it is generally found in high condition, I think it may be a long-lived animal.

Man appears to be its principal enemy. The earth is never found to adhere to the soft fur of the Mole, but the feet or paws, which are without fur, are often covered with mould when captured. Purses are made of its skin by country people, and a molecatcher may be seen with a waistcoat made of the same material.

The peculiarly hidden life of the Mole prevents my enlivening this paper with interesting anecdotes. I copy, however, one which I found in "Science Gossip," which will illustrate its voracity.

"Last winter, when the ground was frozen very hard, I saw a bewildered Mole trying with all his might to bury himself in the ground. I soon captured the little beast and pocketed him. In my walk I espied a poor field mouse, running about for shelter; him I easily captured, and put into the same pocket, which was large and capacious. Very shortly after the introduction, I found a considerable disturbance was going on between the two, and supposing they were trying to escape I closed the pocket to prevent it. I reached home in about half an hour, when, what was my surprise, on feeling for my captives, to find the poor mouse gone, all but his head. The Mole had disposed of him. I then placed the survivor on the table, laying the head before him, when, with all the coolness imaginable, he picked the bones of his unfortunate companion, taking no heed of several persons who stood round."

With regard to the usefulness of *Talpa* as a civil engineer, my experience and observation convince me that it is too wandering and uncertain in its digging operations. And where Moles are numerous they necessitate much extra work to prevent injury.

On Mr. Mellard Reade's Work on Mountain Building.

By REV. M. B. SAUNDERS.

Read before the Geological Section.

MR. MILLARD READE'S book is very interesting, as being full of facts and experiments, and presenting a theory of mountain building which is not generally accepted.

In this paper I propose to take his side of the question. Let me state at the outset that he entirely rejects that view of mountain building which is based on the secular cooling and contraction of our planet.

On page 267, Mr. Reade writes: "Considering the varying materials of which the interior of the earth is composed, as shown by the diverse composition of erupted lavas, an equilibrium of its constituents has not yet been attained. It is not improbable that large masses of the heated globe, far below the thirty-mile zone, undergo slow changes which produce fluctuations even in that superheated mass . . . the masses so affected must fluctuate in bulk . . . while the extravasation of lava must create an internal flow of the heated magma below the crust, thus bringing its various component materials into juxtaposition." This appears to be the key to Mr. Mellard Reade's theory.

Thus, in a given area such combinations may take place as to produce chemical activity with increase of heat and bulk, resulting in the upheaval of the overlying crust; under other conditions there will be a decrease of activity, with such decrease of heat and bulk as will permit the overlying crust to sink down and form a depression, greater or less in depth and extent.

In order to initiate a chain of great mountains, with its core of archæan rock flanked by sedimentary strata, two preliminary conditions are necessary. The one is, a deposit of sediment on a subsiding area; the other, that this area must be limited, and the depression deep.

Sediment, however, does not initiate subsidence, but its accumulation sinks the crust to a point below that to which its own weight alone would have carried it, nor will the subsidence be counteracted by any great rise of the Isogeotherms due to increased thickness of strata, these being more largely influenced by the condition of the heated magma below the area.

In course of time diminished activity will be succeeded by a return to the normal state, and the Isogeotherms will rise to the level of those in the surrounding areas; at first this will not have the effect of lifting the crust, for its strength has been greatly increased during subsidence—partly, its curves are directed towards the pressure from below; partly, its thickness is increased by the addition of seven to nine miles of sediment. The resistance thus offered affords time for the temperature to rise through the mass until some of the upper strata become sufficiently heated to rise in anticlinal ridges, to be followed by those below, until the archæan crust itself is reached, when this also will rise, forced up under the influence of heat expansion in a more or less plastic state, hence the ridging, folding, and overthrow, which are features of all great mountain chains. Besides this, the archæan rock, being more heated and possessing greater expansive strains than the overlying sedimentaries, must break through them, showing itself in the higher peaks, while the sedimentary strata rest on the lower flanks.

These considerations imply that the initial upheaval of our great range has been geologically rapid. After this we have abundant evidence of variation in subterranean activity, each pause and each renewal of activity adding to the complexity of the phenomena; but where movement has been once initiated, there it seems to continue. The Pyrenees afford an interesting example of this. Raised first in early Palæozoic times, then depressed for a long period, after that subjected to two more great movements and three of lesser importance, for seven in all participated in the formation of this great range. The Himalayas afford another instance of similar alternate and prolonged action. Now, if the formation of these ranges was due chiefly to secular contraction, though we should expect pauses in the process, yet there should be no depression—whatever action there was must force the mountains upwards, as it compressed the area on which they stand. But if the formation of the mountains is due to altered conditions of the subjacent magma, then this elevation and depression is in harmony with our theory.

Another important point. On the theory of secular contraction, those parts of a district which lie on either side of a mountain range must travel over several miles in their approach to each other. American geologists state that abundant evidence of such translation exists. Taking the measurements across the Alleghany chain; the present extent of the sedimentary strata, measured over hill and dale, proves such a movement to have taken place; *i.e.*, if the sedimentary strata were flattened out they would stretch several miles beyond the present breadth of that chain. To which Mr. Reade's friends may reply—first, that the heat which gave rise to the mountains expanded and extended these strata: second, the upthrust of archæan rock has not only driven aside the sedimentaries, but also has itself further expanded, and these expansions have so complicated the measurements that they do not even proximately represent the extent of the original beds. On the other hand, Mr. Reade's theory does account for the undoubted fact that a much greater surface is covered now by these strata than is implied by a straight line across the chain, which we suppose to be the approximate width of the original beds.

The effect of secular contraction on the crust is disposed of by referring the whole to normal faults, which are found everywhere, indicating that these evidences of tension strain have affected the crust pretty evenly throughout its entire extent and thickness, sufficiently accounting for all the contraction which can reasonably be supposed to have taken place since the formation of the solid crust.

Do Snakes Fascinate their Victims?

By Dr. A. J. HARRISON.

Read February 7th, 1889.

IT is a time-honoured belief that snakes have the wonderful faculty of fixing or fascinating the creatures they feed upon, either by the power of their eye or by their very presence, so that victims become an easy prey to their destroyer. This question has exercised my mind for a long time, and I therefore determined to see how far the opportunities I had for making observations at our Zoological Gardens confirmed this opinion or otherwise.

At the outset I particularly wish to emphasize this point, that if any observations I bring forward may seem to some here to be heartless and forbidding, I do hope they will let me assure them, once for all, that I have no desire to appear in the light of a cold-blooded observer, indifferent to animal sufferings, but that I was determined to approach the investigation of this subject in as calm and philosophical a spirit as possible. Snakes, like all of us, must eat to live, and I cannot allow that my presence, and that of friends on several occasions, added one iota of suffering to the snakes' victims.

There can be no doubt that from time immemorial snakes have been regarded with awe and superstition. We have marked evidence of this in the marvellous properties assigned to them, in the very names of them, and in the history of the basilisk itself, which was supposed to be hatched by a serpent from an egg laid by a cock. We see exaggerations again in the recorded size of snakes connected with ancient history, and in many other wonderful stories, which are too many and too long to be discussed in this abstract.

I will now pass on to relate observations made by myself, either alone or in the presence of friends. First of all, then, I will summarize some general observations which I have made extending over several years, and which first of all gave me the cue, so to speak, of beginning to question the marvellous powers of fascination which have been attributed to snakes. Thus I have on many occasions seen rabbits and fowls put into the cage with the Python, when he was "on his feed." Bunnie has gone about in a most unsuspecting manner, poking his nose at the snake, and the serpent in his turn put out his head and project his forked tongue at the rabbit. I have seen one rabbit resting on the body of the recumbent snake, and another hopping about over him. A note I made more than a year ago is to this effect: "I have seen a couple of fowls strutting about in the Python's den without evincing the slightest alarm, and I can quite imagine a young cockerel saluting the morning perched on the body of his rapacious enemy." Next I wish to refer to and describe, more or less minutely in some instances, more particular observations.

On Wednesday, January 19th, 1888, the large Python in our "Zoo" was said by the keeper to be "on his feed." We had kept him without food for several days after he showed signs of hunger, such as brightness of his stony-looking eye, slight increase in temperature, and restlessness. At 4.30 p.m., when the house was shut up from visitors, four nice-sized ducks were put into the cage. They fluttered and scrambled about at first, but this was no doubt in consequence of being released from their hamper and the strangeness of the place. The cage is about four yards long, and the ducks were put in at the end farthest from where the snake was. He raised up his head, showing his buff-coloured throat and neck, opened his mouth, and in a moment made a dash at one of the ducks, and seized it by its head. At the same time he rolled his body about in a strange vermicular manner, and most adroitly entangled another duck in his coils, and nearly succeeded in grasping a third. The Python then remained quiet, and we concluded he was slowly absorbing number one duck, as we could see only a portion of one wing. Number two was encoiled, but, presently pushing his head out from the coils, did not seem at all uncomfortable, certainly not alarmed, and not fascinated, for he moved his head about.

We waited ten minutes, and then, as there seemed no change, we opened the cage door close to the snake, and stirred him up with a stick. Presently he raised his head up out of his coils, and we saw that he had released number one from his mouth, evidently quite content to keep his prey close at hand to be enjoyed at his leisure. By stirring the Python up, we released number two from the coils a little, so much so that he got his head and neck free, and his beak came close to the glass of the cage, and for some minutes I could watch the expression of his eyes. He breathed occasionally, moved his head about slightly, and even in this predicament did not seem to show the slightest alarm. After waiting about five minutes more, we drove the other two ducks towards the snake. He raised up his head,—still keeping number one encoiled,—made a dash at another duck, but failed to secure it, and in writhing about allowed number two to escape, who waddled about and preened his feathers, apparently very little the worse for his imprisonment, and fraternized with his other two companions.

It very quickly became so dusk that we could see no more proceedings, so the keeper (Sage) and I left the serpent and his victims. When the keeper visited the house the next morning at eight o'clock, the four ducks, feathers and all, had entirely disappeared.

My note-book contains the following sentence: "The fascination of snakes over their victims may, I think, be relegated to the remotest regions of romance."

On Friday, October 19th, 1888, Sage, the keeper of the Bird and Reptile House, thought the large Python would feed, as he had nearly completed the casting of his skin, and had not fed since the end of August. To some persons this interval of time may seem long for a living creature to go without food. I may assure them that for Pythons it is not an unusual time. A large Python we had in the "Zoo" some years ago lived for eighteen months without food, but then it died.

However, to return to our living Python; he seemed lively, raised up his head, and kept opening his mouth, gaping widely. These are all considered signs of being "on the feed," so, in the presence of the Honorary Secretary of the Gardens, Colonel Jones, Colonel Graham, Mr. Charbonnier, myself, and the head keeper and Sage, a fowl and a duck were given to him. He stretched out his head and regarded them with his stony eyes, opened his great mouth again and again, and evidently seemed to be anticipating a choice repast.

However, in a few minutes he became quieter, settled down, and thrust his head amidst his coils.

We now opened the cage and drove the birds towards him again and again. They passed over his body. This roused him; he would stretch out his head and his mouth close to the duck or the hen, whichever happened to be nearer. Shortly he settled down again, and so, as it was evident he didn't intend to feed to satisfy our curiosity, we had the prey removed, and determined to make him wait a few days longer, expecting that enforced starvation would sharpen his appetite.

That the fowl and duck should be at first disturbed by the new surroundings was not in the least surprising, but they certainly were not spellbound. On Monday, October 22nd, 1888, at five p.m., two fowls and a duck (the latter and one hen our former friends) were placed in the Python's cage. He seemed less excited than on the former occasion, and hardly noticed them at all. We drove them about, and they strutted over or perched upon the body of the snake. Very shortly, whilst the two hens were actually perching upon him, he raised his head and sniffed at them, as it were. One hen resented this proceeding, or mistook his delicate tongue for a worm, and pecked at him. This so astonished him that he suddenly darted his head back, and with such abruptness that the movement startled the hens. During all this time the duck was squatted down close by the side of the Python, and evidently seemed to be settling down for a comfortable roost through the night, fast coming on.

The hens cackled and strutted about, and evidently had not the slightest conception of the presence of a direful foe. As matters seemed to be going on very quietly, we (Colonel Jones, Dr. Shaw, Mr. Charbonnier, and the two keepers and I) drove the birds about; and now occurred a very ludicrous incident. The duck settled himself down amongst the coils of the snake, and then attacked the snake by pecking at some loose bits of a portion of the unseparated slough on the snake's body. The positions of victim and victimizer were reversed! As the keeper, Sage, did not like the idea of all the birds being removed, one hen was left as a solatium; but I think theoretically we may opine that the snake was really thankful to be relieved of two-thirds of his tormentors, and would probably have preferred the absence of the remaining third, for it turned out that the Python did not feed.

On Saturday, October 27th, a little after five p.m., the keeper placed the duck in the cage, several of the former witnesses being present.

Almost immediately the duck waddled over the snake's body, who seemed to resent the intrusion by stretching out his head in a lively manner; but a sudden peck of the duck's beak, followed up by an attack on the body of the snake, speedily sent the inquiring head back again amongst the coils. There seemed no fascination here!

We left the duck in the cage, and we all thought it would have disappeared by morning. At the same time a young rabbit was placed in an "Aboma's" cage close by. The snake stretched out his head in a very quiet, subtle manner towards bunnie, who showed not the slightest alarm. When the keeper visited the house next morning both duck and bunnie had disappeared. On Friday, November 2nd, a duck was given to the Python, who seemed very lively; and a little while later, the white hen was also put in. Neither birds showed the slightest alarm.

At the same time two little rabbits were placed with the Aboma. They were not in the slightest degree disconcerted, and one actually played with and fondled the snake's head.

The next morning the Python had killed the duck, but not swallowed it; the fowl was untouched. From the fact that the duck was cold and already smelling from incipient putrefaction, we concluded that the murderous onslaught had taken place soon after we left. The duck had evidently been seized by the neck, as the teeth marks were there, and it was moist and sodden. It might have been partly gorged and then rejected, as snakes not unfrequently will do this. If they are disturbed or threatened with an attack, they will do it to facilitate their escape. The rapid decomposition of the duck was due to the warmth of the house, and also, I expect, to the salivary fluid of the snake.

The Aboma had caused the disappearance of both rabbits. On December 11th, the white hen and a duck were placed in the Python's cage. The hen showed not the slightest fear. In the morning neither had gone. On December 14th, at four p.m., the white hen was again placed in the cage. It showed no sign of fear, but settled down on the body of the snake, who seemed fairly lively. At 4.55, as it had not fed, a nice young duck was put in also to tempt his appetite.

As the Aboma had not fed for a fortnight, two white rats were placed in the cage. In a few minutes it slowly pushed out its head and neck and a portion of its body, the rest of the body and the tail remaining almost fixed and motionless. Slowly it approached one of the rats. The rat didn't show the slightest fear, but sniffed at the snake, apparently regarding it as one of the most harmless things in nature, when in a moment, like a lightning flash, the Aboma seized the rat by the nose with its jaws, and instantaneously had wrapped it round with a couple of coils. The rat was grasped so suddenly and completely that it had no chance of squealing. You could only see the posterior end of the rat and its tail, which by the convulsed movements which speedily followed, showed that the rat was being strangled, and quite unable to breathe. In about five minutes after the rat had been seized, we opened the cage cautiously, and by means of a stick opened up the snake's coil, and thus liberated the rat. The rat was dead, asphyxiated. We closed the cage door and watched. It took no more notice of the rat, but slowly and very cautiously approached the second victim, which was in a corner of the cage. The rat sniffed about, but evinced no fear, although it must have witnessed the destruction of its companion. Suddenly, as before, the snake seized the rat and encoiled it. The same thing happened as with the other, and in a few minutes the second victim was dead.

Slowly it relinquished its prey, and left it resting in the water-bath in the cage; and then, placing a few coils of its body near the tail end upon the rat, it gradually approached the first one, which was in the centre of the cage, quietly grasped it by the nose and head, and commenced the process of sucking it in. As soon as it had got a fair grasp of the head, it quickly threw a coil round the body, in order no doubt to compress it, and make it more convenient for gorging. There was a very free discharge of lubricating mucus from the salivary glands of the snake's mouth, the jaws and throat began to expand enormously, and gradually the rat to disappear, and in about twenty minutes the whole process of swallowing was completed, and the head and neck of the snake began to assume normal proportions. It was quite astonishing to see how rapidly the parts regained their natural conditions. After resting for about ten minutes it gradually approached the second rat, and the same processes were repeated. It now became too dark to discern anything more. On Christmas Eve, our old acquaintance, the white hen, and a duck were placed in the Python's cage, and in the morning both had disappeared. These constituted his last meal for the year. Sage, the keeper, computes that he had consumed in the year twenty-two ducks and two hens, weighing on an average about three pounds each.

I have now placed before you all the important observations which have come under my own personal notice; but before making some general comments on the facts before us, I should like to refer to some observations which have been made by other observers on the subject. In *Longman's Magazine* for April, 1888, is a very interesting article on "Something about Snakes," by Mr. C. T. Buckland, F.Z.S., a cousin of the late Frank Buckland. On page 648, speaking of Pythons, he says: "With a rapidity that can hardly be conceived, a rat is seized and a fatal coil passed round, squeezing all life out of it, and reducing its body to the form of an elongated sausage, which the snake lubricates with its slime, and swallows entire."

"If a fowl is put into the cage, no notice seems to be sometimes taken; and the frightened bird, finding that no harm comes to it, begins to ruffle its feathers and to peck about, occasionally trying its beak on the snake's skin. Suddenly the snake has moved and the fowl has disappeared, and can only be detected by the end of a feather or two protruding from the coils in the Python's neck, which have crushed the bird's life out." On page 652 is the following passage: "When a large snake catches a small frog, it is all over in an instant; but if a smallish snake catches a large frog, so that he cannot swallow it at once, the frog's cries are piteous to hear."

Miss Catherine Hopley, in her interesting work on "Snakes," has a word to say about the "fascination of the serpent's eye." She considers that the curiously vibrating tongue of the snake certainly attracts birds—small birds like sparrows and finches. Some would venture on a close inspection, and remain gazing at it, or even peck at it until a movement of the snake told them that the motionless object from which that wriggling thing protruded was a living animal.

Then they might hop away indifferently, happily unconscious that what they had perched on as a branch or a log was animated with a hungering after themselves.

Observation of nature and an inquiry into causes will often present very commonplace reasons for what appears to savour of the marvellous. A snake has just made a meal of some fledglings. The mother bird has witnessed her offspring vanishing by degees, and she frantically hovers over the reptile, fluttering to and fro, and probably uttering cries of distress or enticement, in the hope of her young ones' return. Birds have been observed even endeavouring to rescue a seized fledgling. The naturalist comprehends the reason; the poet thinks the birds are "fascinated."

Dr. Stradling, in *Land and Water*, April 2nd, 1881, describes a hen that had been placed in an anaconda's cage, making a determined dab at the snake's tongue; and he comes to the conclusion that she "mistook the tongue for a wriggling worm."

Mr. Frederick A. Lucas, the Secretary of the "Trenton Natural History Society," regards the "fascination" as being the outcome of "a strong sentiment of excessive repugnance, if not of actual horror," which the members of the snake family produce in the human breast.

However, I think I have trespassed upon your time long enough, and therefore let us summarize.

We have looked at the snakes of heathen mythology, and their historical successors, their enormous size, their dragonian appetites. We have dared to look at that compound of snake and bird, the basilisk, fully in the face, and its deadly glance has proved no worse than a harmless smile; its purple crown has been transformed into a simple hood. But superstition and ignorance are very difficult to eradicate, and therefore it is not surprising that the myths of heathen mythology, with all their exaggerated fancies, should still throw a colouring halo over the ideas of the present day.

Had snakes ever attained the enormous proportions assigned to them by the ancients, we should surely have some geological proofs of the fact.

Without going into all the particular evidences of this part of my subject, I may state briefly that there have been no geological remains found bearing out such opinions, nor have any skeletons or portions of bony structure been discovered in more modern times which would indicate that snakes existed which were larger than those known to exist in recent times.

Then, I have referred to the experiences of some of our best observers, and I have ventured to detail my own investigations into the proceedings which these reptiles take in order to secure their food; and putting all these things together, we find we have to represent the largest snakes in existence, and which probably ever did exist, an ophidian, it may possibly be, 30 feet long, possessed of enormous power certainly, but characterized still more by its clever mimicry of nature,—be it branch of tree or log on the water,—by its wriggling and darting tongue of worm-like affinity; and, lastly and chiefly, by the most intense form of subtlety, which does pervade, or ever has pervaded, any living creature; and reflecting upon all these things, the words are inborne on our minds, "Now the serpent was more subtil than any beast of the field, which the Lord God had made."

Mimicry amongst the Lepidoptera.

By G. C. GRIFFITHS.

Read before the Entom. Sect., March 11th, 1889.

THE earlier entomologists did not fail to notice the remarkable superficial similarities which so frequently exist between species of the same order, widely differing in structure and affinity, and even between insects of different orders, or,—extremest instances of all—between insects and inanimate objects.

Kirby and Spence, in their chapter on the Means of Defence of Insects, refer to some larvæ living in the nests of humble-bees, "the offspring of a particular genus of flies" (*Volucella*, Geoff.—*Pterocera*, *Meigen*), many of the species of which flies strikingly resemble those bees in shape, clothing, and colour. "Thus," they remark, "has the Author of Nature provided that they may enter these nests and deposit their eggs undiscovered. Did these intruders venture themselves amongst the humble-bees in a less kindred form, their lives would probably pay the forfeit of their presumption." Boisduval, in his "Species Général des Lépidoptères," remarks that "Nature in certain cases has reproduced the same design and same colour in genera sufficiently remote. Thus, for example, the *Zygænidæ* have, in this respect, the greatest similarity with *Euchelia jacobeæ*, *Syntomis phegea* with *Zygæna ephialtes*, *Danais chrysippus* with *Diadema bolina*, female, *Danais archippus* with *Diadema disippus*, *Pieris pyrrha* with certain *Heliconii*, *Nemeobius lucina* with *Melitæa*, etc. That which is still more remarkable is, that beyond the analogy of colour and design, Nature has given to these species the same habitat, and has created them side by side with one another." He goes on to mention the analogy in appearance between certain of the diurnal and nocturnal *Lepidoptera*, also between many of the *Lepidoptera* and insects of other orders, such as the similarity between many of the *Sesiidæ* and the *Aculeate Hymenoptera*, so familiar to English entomologists. Thus far, however, little more than the bare facts had been noticed; the material for theorizing was at hand, it remained for some observer to collect it and to find the clue.

This honour belongs to Bates, who, in the silence of the South American forest, thought out the theory of Insect Mimicry, which he gave to the world in his book, entitled "The Naturalist on the River Amazons." At Villa Nova he found an exceedingly handsome butterfly, *Agrias phalcedon*, greatly resembling another, also found there, *Callithea leprieurii.* Also, on the Upper Amazons he noticed a totally distinct species of *Agrias*, mimicking still more closely another *Callithea*; both insects being peculiar to the district where they are found flying together. His reasoning upon this fact we will give as far as possible in his own words: "Resemblances of this nature are very numerous in the insect world. I was much struck with them in the course of my travels, especially when, on removing from one district to another, local varieties of certain species were found, accompanied by local varieties of the species which counterfeited them in the former locality, under a dress changed to correspond with the altered liveries of the species they mimicked. One cannot help concluding these imitations to be intentional, and that Nature has some motive in their production. . . . I believe these imitations are of the same nature as those in which an insect or lizard is coloured and marked so as to resemble the soil, leaf, or bark on which it lives; the resemblance serving to conceal the creatures from the prying eyes of their enemies; or, if they are predacious species, serving them as a disguise, to enable them to approach their prey. When an insect, instead of a dead or inorganic substance, mimics another species of its own order, and does not prey, or is not parasitic, may it not be inferred that the mimicker is subject to a persecution by insectivorous animals from which its model is free? . . . In the present instance it is not very clear what property the Callithea possesses to render it less liable to persecution than the Agrias, except it be that it has a strong odour somewhat resembling vanilla, which the Agrias is destitute of. This odour becomes very powerful when the insect is roughly handled or pinched; and if it serves as a protection to the Callithea, it would explain why the Agrias is assimilated to it in colours."

This suggestion of Bates as to the odour of the Callithea supplies the key to the mystery. We find, even in an examination of the comparatively scanty insect-fauna of our islands, numerous instances in which, either on account of taste or odour, an insect is distasteful to its inveterate foes, and in this fact finds its protection and well-being. Amongst these may be mentioned *Euchelia jacobeæ*, *Abraxas grossulariata*, and *Chrysopa perla*. But if in our temperate climate, by no means over-peopled by predacious birds and insects, there is need for such a device, how much more in a tropical region, where life of all kinds is abundant and the struggle for existence tenfold more keen. Wallace says that "in the Brazilian forests there are great numbers of insectivorous birds—as jacamars, trogons, and puff-birds—which catch insects on the wing, and that they destroy many butterflies is indicated by the fact that the wings of these insects are often found on the ground, where their bodies have been devoured." And, beside the birds, the rapacious dragon-fly follows its flying prey with wings swifter still, whilst the insect at rest on the tree-trunk falls into the power of the spider or lizard, or the mantis lying in wait, disguised as a bundle of leaves, or the phasma lurking among the dead twigs, itself as stick-like as they. From all these dangers, likeness to a species malodorous or distasteful would give to the insect assuming it protection more or less complete: not entire protection, for it has been proved by experiments that the hungry bird or lizard will approach and devour a species which it at first believed to be distasteful, though only after much preliminary care and examination; so that the temporary hesitation of its foe would in natural conditions give the attacked insect many chances of escape.

Amongst the Diurnal Lepidoptera we find two families in particular, the *Danainœ* and *Acrœinœ*, which are distasteful to birds and other animals; and even apparently after death this characteristic protects their bodies from the inroads of the acarus. Hence, as we might expect, we find that most of the mimicking species bear a resemblance to one of the species of these two families.

In some cases both sexes share this immunity, but in others the female only is protected by likeness to the nauseous insect; it being most important to the survival of a species that the lives of the majority of its females should be prolonged until deposition of the ova has taken place. In a few instances certain individuals only of the female sex depart from the normal form of the species and assume a mimetic resemblance to one of distasteful character. Such is the highly specialized variety of the female of *Papilio Merope*, which bears so strong a resemblance to the Danaid *Amauris Niavius* as to have been described under that name by both Cramer and Gödart. Boisduval, who recognised it as a Papilio, did not suspect its relationship to *Papilio Merope*, and named it *P. Westermanni*. It is singular that *Hypolimnas Anthedon* is also an exact mimic of *A. Niavius*. *Hypolimnas misippus* (female), which species occurs in Asia and Africa, bears an almost perfect resemblance on the under side to *Danais chrysippus* and its African form *Alcippus:* the former species indeed occurs also in Trinidad, Cuba, and Florida, where *Chrysippus* is not native, but as it is a migratory insect, and has been met with at sea at great distances from land, it has probably been introduced. *Papilio Clytia* bears a strong likeness to a Danais, probably *D. Limniace*, whilst *P. panope*, which Mr. Elwes ("Lepidoptera of Sikkim": *Trans. Ent. Soc.*, 1888) is assured is only another form of the preceding species, may be easily mistaken for *Euplœa core* when on the wing. *Papilio paradoxa*, *P. ænigma* and *P. telearchus* are mimics of *Euplœa midamus* and its allies. *Euripus halitherses*, female, bears a strong resemblance to *Euplœa rhadamanthus*, and, according to M. de Nicéville, "not only in form and coloration, but also in the slow-flapping flight and the habit of settling in open places so characteristic of *Euplœa ;*" he adds that the male, which is not similarly protected, "has a rapid flight, and never settles with expanded wings in conspicuous places as the female does." *Papilio caunus* also mimics *Euplœa rhadamanthus*, whilst, according to Distant, the Malay form of the Papilio (*P. ægialus*) finds its analogue in the local Malay race of the Euplœa (*E. diocletianus*), and he also states, on the authority of Salvin, that Bornean examples of the Papilio mimic the Bornean race of the Euplœa (*E. Lowei*). *Papilio Adamastor* and *Pseudacræa Semire* are both mimics of African species of Acræa.

Elymnias also is a strongly mimetic genus: the female of *E. undularis* resembles in some degree *Danais Plexippus*, or other of the tawny Danaids, other species approximate to the blue Euplœas, of which *E. midamus* is the type, whilst one of the African species, *E. phegea*, mimics an *Acræa* found in the same locality.

Leptocircus curius, *L. meges*, and *L. virescens* appear to mimic dragon-flies in their manner of hovering over water. Mr. Forbes ("Nat. Wand. East. Archipel."), speaking of the last-named, says: "By the margin of a small stream I caught *L. virescens*, which derives protection from mimicking the habits and appearance of a dragon-fly, in a crowd of which it is often to be found. In form it reminded me of the European genus *Nemoptera*. It flies over the top of the water, fluttering its tails and jerking up and down, just as dragon-flies do when flicking the water with the tip of their abdomens."

In examining these species we cannot avoid noticing the different manner and varying degree in which protection is afforded to edible butterflies by their resemblance to distasteful kinds. Some, which resemble their models only on the upper side, are protected only during flight when in danger from birds and dragon-flies, which would usually attack on a level or from above. Others, whose underside only resembles the nauseous species, find safety from it only when at rest; whilst again there are species amply guarded both above and below. Many more cases of mimicry might be cited which are exclusively of the same kind, namely, the imitation of one insect by another; but beyond these there is another class of instances in which insects escape danger by assuming the appearance of objects belonging to the vegetable or inanimate kingdom, such as the striking similarity of the underside of *Kallima inachis* to a withered leaf. These however belong rather to the wider subject of Protective Resemblance, and not to the one phase of it just considered.

On Putrefactive Organisms.

By THE REV. W. H. DALLINGER, LL.D., F.R.S.

Abstract of Report of Address Delivered November 6th, 1888.

THE author said his difficulty was to decide in which way to treat his subject. He might summarize the investigations of twenty years, and endeavour to show the original motives which led to their being undertaken, and then contrast this with the new meaning which has been derived from the investigations founded on recent methods and instruments; or, secondly, he might show the results of a series of continuous observations on certain saprophytic organisms placed under increasingly adverse environments, so as to endeavour to discover their behaviour in regard to the great Darwinian law. He inclined to this last as the view of his work that might have the broadest interest to a Society like that he was addressing; but the value of the improvements in recent lenses led him to give the priority to the results so obtained. In the case of larger animals, it was well known that a change of environment produced changes in the structure; but that these changes were hard to follow up, owing to the few generations that come under the notice of the student or observer. But in the case of micro-organisms the generations succeed each other so rapidly that it is easy to follow the changes produced by environment. He could show the effect on certain micro-organisms of a gradual change of temperature, and how in from seven to eight years an organism arose which lived and multiplied at a temperature of 157° Fahrenheit, whose ancestors had lived at a temperature of 65° Fahrenheit, and would have died if exposed to temperatures above 100°. He said there was nothing harder than to carry an audience to a just appreciation of the lower forms of life, but nevertheless he hoped to point out some of the practical results due to the improvements in modern microscopes. If they took a glass of drinking water and put in it some shreds of fish, or any other organic substance, it soon became turbid and charged with the minutest organisms. To illustrate the number of these organisms, Dr. Dallinger said that visible to the human eye in the heavens there were in all probability with our most powerful modern telescopes, 100,000,000 stars; and if they supposed that each of these, like our sun, was attended by eight primary bodies and twenty secondary planets, there would be two thousand eight hundred millions of bodies in space accessible to human research. The same number of these minute organisms to which he had referred would lie in a space equal to one ten-thousandth of a cubic inch. Any such a molecule of even dead matter must arrest the attention of the human mind; but when we remembered that these were complex *vital* forms, they had a significance of a high order, and their inconceivably rapid multiplication would make the mind pause and think. A decomposing mass of matter was a mass of beings endowed with life, and producing definite products. The life of the organism was not even an incidental product, the organisms were there for a purpose. They break up the decomposing organic matter into its elements, and so make it ready again for the purposes of life. Dr. Dallinger then went on to describe some of the organisms which he has observed and examined. ~~He~~ said, that if they took some putrescent fluid from different putrefactive material, and mixed them, then put a very minute quantity of sterilized fluid on the microscope slide, and put into this the point of a needle which had been inserted into the mixture of putrefaction, and examined it with a sufficiently powerful microscope, the field of view in the microscope became, as it were, charged with life in an instant. There were many kinds of organisms, and they had many movements. There were rod-shaped organisms, spiral forms, a perfectly oval form with two flagella, or whips. Another would be like the calyx of a papilionaceous flower, and have four flagella. Another would have a delicate egg-shape, and another be shaped like a double convex lens, and move with a beautiful wave motion. The fluid speck seen under the microscope was densely peopled. What were these organisms, and what their functions amid the denizens of earth? They were extremely small, and the largest of them so small that one hundred millions could be packed within a cube whose side was equal to the diameter of a single human hair, and there were from ten to twenty less than this. This group were amenable only to the most powerful microscopes. It was known long ago that they carried on putrefaction; now they knew that the process was a fermentation. Dr. Dallinger then went on to contrast ordinary saccharine fermentation, like that of yeast, producing carbonic acid and alcohol, with the fermentation produced by these saprophytic organisms, and showed that both could be prevented by taking care to keep away any of the germs of the fermentation, that both could be arrested by the action of heat, and that both tended to break up the organic matter into simpler forms. In the case of the saprophytes, water and carbonic acid were produced eventually from the decaying mass on which they dwell, and thus by the vital functions of these organisms the chemical elements in the animal body were restored to nature, to become once more part of the protoplasm of living things. There were, however, two things in which these saprophytic ferments were different from ordinary ferments; in the latter a special organism produces a special product, whereas in the former there was no such definite product, and in the saprophytic ferment the final process was produced, not by one definite organism, but by a series of organisms. He did not think that these ferments destroyed one another; but between the beginning and the end of the putrefaction there was a definite incoming and disappearance of many forms. In from 50° to 60° north latitude, he believed these organisms were limited to ten forms, and of these eight were definitely determined, and their life-history made out. There were some present everywhere, and they acted at once. Dr. Dallinger said the object of his study was biological, and not pathological. Some of the results he discovered some time ago, but the large progress of recent years was due to the great improvements in our instruments. These organisms were all different, no two of them behaved alike. He said that if they added a very small quantity of putrescent fluid to a speck of water on a slide kept at 65° F., it was very easy to find some of these organisms almost directly, using a lens magnifying 1,000 diameters; and they would be found to increase with a rapidity that no description could suggest. He then showed on the screen the first kind of organism that appears, and mentioned that when seen in reality, they were in a constant state of movement, and that the saprophytic ferment begins to split up and break down the organic tissues. This first organism, Bacterium Termo, would produce profound changes in the putrefying tissues, and prepare the way for other organisms. It would be seen that this organism would be densest round the mass that was being broken up, forming a felt-like covering or garment to it; soon a new organism of a spiral form would make its appearance (this was shown on the screen), while Bacterium Termo would become less abundant, and be diffused over the entire fluid. The new one, like Bacterium Termo, would be densest next to the putrid matter, and would form a covering to it. The decaying tissue would now rapidly change, and would give off noxious gases. This form would continue for an indefinite time, and be succeeded by one or two new forms. (These were shown on the screen.) One of these new forms would have a single flagellum, and the other would have two; and they would move rapidly about and glide continuously over the decomposing matter. They increased very rapidly, one method of increase being by a process of division. In another method two bodies would unite together, and an amœboid condition ending in the *fusion* of two forms resulting in a sac from whence spore was produced, giving rise to new generations. Their rate of increase was inconceivably rapid, and it was not surprising that the putrid tissue was surrounded by a garment of these organisms. They had in all probability their food and suitable conditions for their life produced by the functions of their predecessors. Then a time came when this form died out, and a very remarkable organism appeared which also invested the putrid matter with a garment of living organisms; they stuck to the mass and waved to and fro. These were shown on the screen as they would be seen in the microscope, clustering round the matter. With this was shown the next organism—a most wonderful one. It has a rigid flagellum armed with a hook and a long trailing flagellum. The animal swims about, and when it comes to a piece of decaying tissue, it often anchors itself by the trailing flagellum, which is coiled into a spiral; then it darts up and down upon the decaying matter. The action of this was shown by a mechanical slide, the up-and-down motion and the coiling and uncoiling of the flagellum being seen. These were succeeded by a group which had a rigid flagellum without any hook, and which fastens itself down by means of its trailing flagellum, and hammers the decomposing tissue by throwing itself against it. This process was also shown on the screen by means of a mechanical slide. Dr. Dallinger said that this occurred at about the middle of the putrefactive action, the greater part of which is accomplished by this. The mass now gradually broke up. The next kind, which was also shown on the screen, and its process explained by a mechanical slide, has two trailing flagella by which it anchors itself; it then springs up and darts down, and assists the decomposition. At the close of this stage there is little left of the original tissue but some water charged with carbonic acid, and a slight deposit of fragments. Dr. Dallinger said that four years ago he found a new organism which acts as a gleaner, and gathers up the fragments of the *débris* left by the others. It is armed with six flagella, and swims about in the liquid, and when it comes within a certain distance of the solid remnants twists its middle flagella together, and springs up and down on the *débris*, removing entirely tiny particles. They move in a most beautifully rhythmic manner up and down. He showed a picture of these on the screen, and also a mechanical slide of a group of three, with their pretty rhythmic action. And thus the organic tissues were broken up into their ultimate elements.

Dr. Dallinger mentioned that the last form was comparatively rare, and was more frequent in warmer countries. It was clear, he said, that different climates had definite forms. In conclusion, he said that twenty years ago, when in a state of ill-health, he took to this research, and found all these beauties and a thousand times more ; and he urged those present to take up some field of microscopical research, and seek for the hidden beauties of Nature. They would find much pleasure in the doing of it. They need not be appalled by the high powers he had used ; there were many facts to be found by the help of far lower powers. If they did this they would find that life would have a pleasure it had never known before.

A hearty vote of thanks to Dr. Dallinger for his extremely interesting and lucid paper, was proposed by Professor Lloyd Morgan, and seconded by Dr. Beddoe. The motion was carried by acclamation. Dr. Dallinger briefly replied and the meeting then terminated.

Some Remarks on Sewerage Systems.

By ALBERT P. I. COTTERELL,
Assoc. M. Inst. C.E.

Read before the Engineering Section, Oct. 16th, 1888.

IN laying this paper before your Society, I feel no apology is needed for the subject dealt with, as the problem of the collection and disposal of the refuse of our communities should, and must always, be a matter of universal popular interest; whilst the important works consequent upon the fierce light of modern science that has been brought to bear upon the subject, and consequent also upon that essential feature of the nineteenth century—co-operation, have brought it so specially within the domain of the engineer, that it becomes a fit subject for our discussion.

I must, however, plead, on account of its vast extent, to being only able to lay a portion of the subject before you.

In the first place, I propose to deal only with that refuse matter most liable to decomposition, and to cause injurious effects, commonly called sewage; and in the second place, to consider only the means of collection and transmission by means of sewers, and not of the final disposal of sewage.

HISTORICAL.

The introduction of drainage systems appears to date from the commencement of civilization. In many ancient cities, such as Carthage, Jerusalem, Nineveh, and Rome, there were complete systems of sewerage. In Rome, under one of the Tarquins, the Cloaca Maxima was constructed: and, though originally intended for draining the marshes, became afterwards used for the purpose of sewerage, and is still used, though some 2,500 years old.

Sanitary science was much better known in the time of the Romans than was the case in the succeeding Middle Ages. It is uncertain whether cesspools were ever used in ancient Rome, but in later times they became almost universal; and, with the decadence in the knowledge of the laws of health, were so carelessly constructed and neglected that they became at last hotbeds of disease, which obliged communities to rouse themselves from their lethargy in regard to these matters. The invention of water-closets, and the increasing density of population in various centres, necessitated the introduction of sewage works on a much larger scale than previously; whilst the improved intelligence of the people, and the great advances of science during the present century, have led to a larger amount of public attention being drawn to these matters than had probably ever been the case before. There are some, indeed, who are beginning to doubt whether, in the craze for sanitation, we are not beginning to overstep the bounds of reason, and to conjure up evils where they probably do not exist. Be this as it may, we have now spent millions in England alone on works of sewerage; and it cannot be doubted that in health at any rate we have so far been benefited. The following statistics, given by Sir Lyon Playfair, conclusively prove this. According to him, the death-rate in London—

in 1660–79 was 80·0 per 1,000;
in 1746–55 ,, 35·5 ,, ,,
in 1871 ,, 22·6 ,, ,,

At the present time it is 18·8 per 1,000.

There are several methods of collecting and disposing of refuse without the use of sewers; such as, by mixture with dry earth; by collection in pails, as in Birmingham and in some northern towns; or in middens or cesspools.

The methods with which we have to do are, however, those in which water or air is largely or chiefly introduced as a means of transmission, and special channels or sewers are constructed. We will therefore deal first with the water-carriage system; second, with the pneumatic or quasi-pneumatic system.

WATER-CARRIAGE SYSTEM.

The water-carriage system is by far the most popular and universal now in vogue. It is pre-eminently a gravitation system, where water, naturally flowing down specially constructed courses, conveys away the refuse put into it. Its chief advantages are:—

1st. That it conveys sewage away quickly, and in the manner least offensive to the eye.

2nd. It requires little looking after.

3rd. By its means the subsoil water may be drained. This is a greater advantage than appears at first sight, as it has been found that the saturation or dryness of the subsoil has an important bearing on health. It has often happened that the sewers have been badly constructed and are leaky, thus admitting the subsoil water; and what was originally a defect has turned out to be an advantage through the good effect produced by the permanent lowering of the subsoil water.

But on the other hand are the following disadvantages, *i.e.*:

1st. It largely increases the quantity of sewage.

2nd. It concentrates the refuse.

3rd. And thus renders it more difficult of disposal.

4th. If the sewer is leaky, it is liable to pollute the subsoil and any wells in its proximity.

The ordinary water-carriage system is divided into two distinct methods, called the Combined and Separate methods of sewerage. In the former, the rainfall is admitted into the sewers; and in the latter, it is as far as possible excluded and carried off in separate conduits. The greater portion of Bristol has adopted the former method; but at Westbury-on-Trym, where a sewage farm is in operation, it is largely excluded. Where pumping has to be resorted to, the introduction of rain-water becomes a costly matter. It is scarcely possible, however, to entirely exclude all rainfall without introducing a duplicate system of drains for each house; and the rain-water falling upon the backyards and roofs therefore often finds its way into sewers. This may be just as well, for rain-water from such parts, especially the first, after a dry period, is quite as polluted as ordinary sewage, and only fit for sewers. In some places special apparatus is designed for the purpose of admitting the light rainfalls into the sewers, and allowing the heavier falls to run into the ordinary channels.

If the rain-water drainage can be separately provided for, and the sewer kept only for sewage, it is without doubt much the best plan, especially when the sewage has to be dealt with. At the same time it must not be forgotten that the drainage of the subsoil water is an advantage, and should be provided for if necessary, although the trench which is cut for the sewer often acts as a drain for this purpose outside the sewer.

As a rule, all new sewerage systems are now designed on the separate method, and the old sewers are used for the conveyance of the rainfall into the natural water-courses.

A good house-to-house water service, laid on at constant pressure from the mains, is in any case absolutely essential to a successful sewerage system. No drain, however well laid, will remain clear unless the sewage is thoroughly diluted with water, and this is never certain of being obtained except with a constant supply. A house-to-house service will also do away with the danger of contamination of the drinking water, where this is drawn from wells.

This leads us on to the consideration of some of the details of a water-carried sewerage system.

The sectional form and dimension of sewers, as well as the materials of which they are constructed, have undergone important changes from time to time, especially during the last half century. The early sewer works were generally put into the hands of most incompetent workmen, and many sewers were merely old water-courses, into which sewage had already been turned, roughly built up in dry walling, and covered with flat stones. (Several instances of this sort have been found in Bristol.)

No attempt was made to render them self-cleansing; and the consequence was that they became "sewers of deposit," into which men had continually to be sent to dig away the accumulated refuse. For this purpose they were made much larger than was absolutely necessary for the work that they had to do. One old sewer in St. Stephen's Street is nearly 6 feet high.

Rough improvements were gradually made, such as arching over top, building invert, etc.; but it is only within the last half-century, under, I believe, the leadership of Mr. J. Phillipps, that sewers were systematically designed with reference to their size, form, and inclination, in order to render them self-cleansing. Their area was largely reduced, and they were so proportioned that with a minimum flow there should be a minimum wetted perimeter. For this purpose the egg-shaped sewer was designed by Mr. Phillips for sewers carrying, or liable to carry, large volumes of sewage.

In smaller sewers circular glazed stone-ware or fireclay pipes are generally used, the circular form being stronger to resist a crushing pressure, and the wetted perimeter being only slightly increased above an egg-shaped sewer of the same dimensions. These sewers are now laid down to 9″ and even 6″ and 4″; but the latter dimension is not recommended, the pipe being liable to get blocked.

Numerous empirical formulæ have been deduced for calculating the velocity and discharge of sewers; but that, I believe, most generally used is Eytelwein's adopted from Chezy's, which runs,—

$$V = 55\sqrt{2\mathrm{Hr}}$$

where V = velocity in feet per minute

H = fall in feet per mile

$$r = \text{hydraulic mean depth} = \frac{\text{area of cross section.}}{\text{length of wetted perimeter}}.$$

It will thus be seen that, the fall being constant, V varies directly as the square root of the sectional area, and inversely as the square root of the wetted perimeter. It is now necessary to find a velocity that will render the sewer self-cleansing. As a rule, a velocity of $2\frac{1}{2}$ feet per second, or 150 feet per minute, is generally calculated for in designing sewers. It should be borne in mind in connection with this, that the velocity of sewage will be somewhat dependent on its purity; for pure water will flow with less frictional resistance than thick muddy water.

Recently there have been many improvements in the materials of which sewers are constructed. In all brick sewers none but the best bricks should be used, of as dense a character as possible, to prevent absorption of sewage. Glazed fire-bricks are excellent. Glazed hollow fireclay invert blocks are often used, and the hollow is utilized as a drain for the subsoil water. In some systems these subsoil drains are specially provided; but they should be used cautiously, as they may easily become fouled from the sewer, and, if the soil is at all loose, may so dislodge it that a settlement of the sewer may take place.

Sewers have been sometimes built up in four or more segmental terra-cotta blocks; and sometimes the bricks have been previously cemented into segments before being placed in position. More recently, concrete sewers have become popular, and concrete and brick or concrete and pipe sewers combined. They certainly have the advantage of being practically water-tight and very strong. Of pipe sewers, either circular or oval sections can be obtained. The former are to be preferred, as being likely to make the best joint. There are a number of different pipe-joints. One of the best is Stanford's or Phillip's, but the plain collar pipe is by far the most commonly used. Great attention should be paid to the cementing material, as some limes (such as chalk lime) cannot resist the chemical action of the sewage. So far as I am aware, London Portland cement has proved itself to be most suitable for the purpose, either used neat or mixed with a little sand. A few years ago clay joints were largely used for pipes; but I trust the day for this unsafe method has gone by. There are times when some clay-jointed sewers may be thoroughly sound; but much more often the clay gets washed out, or rats work through it, and thus ruin the sewer as a water-tight water-way. In some cases, such as passing beneath a house, across streams, or in difficult ground, cast-iron pipes are used, coated inside to prevent rust, and jointed with lead. There is no doubt that this forms a most efficient sewer; but its cost is rather too heavy for general use.

The foundations for sewers sometimes call forth the ingenuity of the engineer. It is most important that the sewer should not shift after being laid in; and this is often rather difficult to obtain in made ground or in quicksand. The usual methods of forming a foundation are generally adopted, such as planking, or laying faggots and then concreting above till the concrete find its bearing, etc. When the sewer is above or near the surface of the ground, piles are sometimes used.

The other details of construction of sewers, such as tunnelling, trenching, running under heavy buildings, etc., need not be gone into here, as they are common to all engineering works, and have already been partially considered by this Society.

In two places in Bristol, and in many other towns, we have to cross the water; and the sewers are carried in inverted siphons laid in the bottom of the river-bed. They are composed of cast-iron pipes with ball and socket joints; and, being laid with ample fall from inlet to outlet, have never caused any trouble.

With the inauguration of smaller sewers, special means of inspection became necessary. This is provided for by manholes, and sometimes lampholes placed alternately upon the line of sewer.

In order to afford ready inspection, Mr. (now Sir) Robert Rawlinson (a Bristol man) introduced the method of laying sewers in straight lines between manholes and lampholes, and giving the necessary curves in the floors of the inspection chambers. A lamp can then be hung in the lamphole, and the man in the manhole can see whether the sewer is clear. In large sewers where men can enter, these straight lines are not necessary. Manholes and lampholes are often used as ventilators now-a-days, and it is then usual to give the sewer a slight drop at that spot, in order to guide an ascending current of air upwards as much as possible. Where gradients are steep these bays are useful in checking the velocity, which would otherwise cause undue wear; but as it has been found by experiment that wherever splashing occurs foul air is generated, I am doubtful if these bays, especially at ventilators, do not do more harm than good.

In addition to manholes, since the introduction of smaller bore sewers, inspection pipes are placed at short intervals of about 100 feet, fitted with movable caps or tops. In case of stoppage these can be opened, and cleansing rods passed through without disturbing the remainder of the sewer. This brings us to another important point, and that is, provision for flushing. This matter might not be so necessary if all sewers were designed and laid out by the formulæ already quoted—to give a velocity of 150 feet per minute. But it must be remembered that the flow of sewage is often so variable that there is an insufficient quantity to produce the minimum velocity, and that this velocity of 150 feet per minute will not suffice to remove very heavy material, such as road-stones and other heavy articles which sometimes (but should not) find their way into the sewers. Therefore it is best, for safety's sake, to provide means of flushing; *i.e.*, means of artificially increasing the velocity. This can be done either by storing up the sewage itself and letting it go with a rush, or by storing water in tanks and letting it suddenly into the sewer. The author inclines to the latter method, because during the process of storing the sewage there is a diminution of the velocity and necessarily a deposition, which is not likely to be all washed away when the sewage is allowed to go.

The sewage is sometimes stored by self-acting gates, which open when it reaches a certain height, or by sluices or penstocks placed in the manholes and lifted by the flushing men. There are several ingenious forms of self-acting flushing apparatus; the most notable and, in my opinion, the most reliable, being Field's self-acting siphon. I have repeatedly tested these, and found them, when properly fixed, unfailing. The whole secret of success lies in the insertion of an annular ring, through which the smallest dribble of liquid is sufficient to set the siphon in action. It is interesting to notice how thoroughly these siphons do their work when used in tanks. The sewers through which the flush has passed look as if they had been clean swept with a brush. In order to render flushing efficient, it should take place often, and before any deposit has time to harden.

The velocity of discharge of the siphon will be proportional to the nett length of the discharge leg less the depth of the surface of the water in tank below the top of the leg. As the tank empties this will therefore vary. Taking a $5\frac{1}{2}''$ discharge leg $3'\ 6''$ long, and reaching $10\frac{1}{2}''$ below the bottom of tank, and using the theoretic formula for falling bodies, $V = \sqrt{2gs}$, the initial theoretical V will be 15 feet per second, and the final V 7·5 feet per second; average, 11·25 feet per second, or 675 feet per minute. This does not allow for friction of the air and in the pipe; but as the action of the siphon tends to form a vacuum, the former will be nil, and the length of pipe is so small that a 5 per cent. reduction will probably cover the latter. This gives an average theoretical velocity of about 641 feet per minute, and an average discharge of about 105·8 cubic feet per minute, which entering a 9″ sewer laid at a gradient of 1 in 100, would fill it nearly full, and maintain a velocity of 240 feet per minute, sufficient to remove broken stones and road detritus.

In practice, however, this discharge is not quite so great, as it takes an appreciable time after the water begins to flow over the lip of the siphon before it bursts into full action; and again, the velocity is largely checked by the weir into which the siphon dips.

In a practical observation on a 1,000 gallon tank, erected by the author at Redruth, with a 5½″ discharge leg, and a nett quantity of 154 cubic feet of water within reach of the siphon, the time taken to discharge from the first dribble over the annular ring was 3½ minutes, giving an average discharge of 44 cubic feet per minute. When at the height the flush three-quarters filled a 9″ pipe laid at a gradient of 1 in 40, which would give a discharge of about 120 cubic feet per minute.

In most sewer systems of the present day, but not all, ventilators are in use, so as to give free communication between the external air and the sewer. These ventilators have long been a bone of contention. At one time they were almost universally in the shape of gratings at the level of the streets; but in many places they are now carried up above the noses of the public in pipes or shafts. In Carlisle the sewers are connected with many of the factory chimneys, which form powerful upcast shafts. It must be remembered, however, that, owing to friction in the sewer, the area of their influence is not so large as we should theoretically suppose.

A very promising, though apparently expensive form of ventilator, is Keeling's, which, by a gas-jet burning in a lamp-post, both induces a current and burns much of the foul air. Cowls have often been placed on ventilating shafts to regulate the air currents, with more or less success. In connection with these, flaps are often used to divide sewers into sections, and also to prevent wind draughts through them.

With regard to all ventilators, it is necessary to remember, that to be efficient they must be of ample sectional area, equal, or nearly equal, to the area of the sewer which they ventilate.

So far I have endeavoured to describe an ordinary gravitation system of sewerage. It often happens that on account of levels it is impossible to deliver the sewage at the outfall without recourse to pumping.

Of pumps there is almost every conceivable variety in use, from the steam-direct acting pump to the hydraulic engine. One of the latest designs is Shone's Pneumatic Ejector, which will be touched upon hereafter. So far, the most economical, where the flow of sewage does not vary to a very large degree, is the direct-acting steam-pump (*i.e.*, with steam cylinder piston working direct into the pump barrel), in which the valves are made specially large and get-at-able, so as to be able to pass or clear any large and coarse substance.

In all such cases, however, it is found necessary to pass the sewage through a screen, to remove all the larger substances; and it is understood that the pump has a sufficient quantity of sewage to raise to enable it to work at its greatest efficiency. It is easy to arrive at the probable quantity of sewage per twenty-four hours, especially if the population be provided with a systematic water supply; but it is generally found that of this quantity about one-half flows off during six hours of the morning, and that the flow is much the least at night. A sump, or an enlarged outfall sewer, is thus requisite, in which the sewage may be stored until there is sufficient to put the pumps to work upon. These storage sewers and tanks are often provided when the outfall is not at all times available, such as on a sewer gravitating into the sea, where the outflow may for several hours be prevented by the tide. In such cases it is usual to close the sewer by a penstock, and let the sewage accumulate until the tide falls sufficiently to allow of its escape. We have a good example of a storage sewer in the 8-foot sewer down Coronation Road, which was designed to intercept nearly all the sewage that now flows into the Avon on both sides, and store it during high-water. At best these elongated cesspools are bad things, as they mean the accumulation of decomposing sewage just where everything demands its rapid transmission.

PNEUMATIC SYSTEM.

Air has been brought in to assist in the carriage of sewage by several inventors. The only two inventions that have been carried into practical effect, so far as I am aware, are those of (1) Capt. Liernur and (2) Isaac Shone. Capt. Liernur's method comprises the laying of cast-iron air-tight mains, creating a vacuum at regular intervals in them by means of a large air-pump at some central station, and thus drawing the sewage along. The mains are laid with short steep inclines and long flatter declines, down which the sewage may gravitate. Special house-fittings are also used. This system does not seem to have spread beyond Holland, where the excessive flatness no doubt renders it convenient to be independent of gravitation as the chief agent toward motion. But there are several serious drawbacks which quite account for its limited use.

Firstly. It is inconvenient and unhealthy to be obliged to retain sewage in the house or receptacle until stated times, instead of removing it directly.

Secondly. There is great liability to break down. (It is imperative to keep the whole apparatus as air-tight as possible.)

Thirdly. As it is impossible to guarantee an absolutely air-tight apparatus, it is necessarily a costly system with regard to the work done.

Fourthly. It requires special fittings in the houses.

Fifthly. It deals only with a portion, and with the more solid portion, of the sewage, such as that from water-closets, leaving a large quantity of liquid sewage to be still dealt with by ordinary means.

The other method of utilizing air has only been in existence about twelve years, and is the invention of Isaac Shone. Mr. Shone calls it a new system—the hydro-pneumatic; but it is properly simply a modification of a gravitation system, in which patent automatic ejectors, worked by compressed air, are introduced for lifting the sewage at various points, and thus avoiding the necessity of flat sewers of deposit, where the lie of the ground does not admit of proper falls by gravitation. In this there is no doubt that Shone's apparatus is a distinct advance in the healthy drainage of towns. Engineers have often been hampered, and costly drainage systems spoilt, by the impossibility, without enormous expense, of obtaining by simple gravitation, either to an outfall or to a pumping station, a sufficient velocity to render the sewers much better than elongated cesspools, always giving off foul odours, and always needing attention.

The Shone system may be shortly stated as follows :—

The usual stoneware pipe sewers are laid gravitating and converging to various stations, which are placed at the lowest convenient points with reference to the general level of the ground. At each station the sewage is received into a Shone ejector, worked by compressed air, which pumps it along cast-iron mains under pressure to the outfall. These ejectors are, therefore, the distinctive features of the "system," so-called. The sewage is delivered through a cast-iron main into the cylindrical vessel. In the delivery-pipe is a box containing a *lignum vitæ* spherical ball, which falls below its seat when the ejector is filling and rises tight against it when discharging. To the bottom of the ejector the discharge-pipe is fixed, and contains a similar ball, which falls down tight on its seat when the ejector is filling and rises when it is discharging. At some central station the air-compressing engines are placed, and a cast-iron air-main is led to each ejector. The compressed air here enters a cylinder in which works a slide valve, which, as it moves to and fro, enables the compressed air to enter the cylindrical vessel into which the sewage is flowing. Inside the cylindrical vessel are a cup and bell upon an iron spindle, which is continued through a stuffing-box in the top of the ejector and connected to the slide valve. The action is as follows: As the sewage flows into the ejector it compresses the air in the bell, causing at last sufficient pressure to lift the spindle. This moves the slide-valve, and immediately admits the compressed air into the ejector, which, closing the inlet ball against its seat and driving the outlet ball above its seat, forces the sewage up the discharge-pipe. When the sewage has fallen low enough in the ejector, the weight of the cup and ball and the sewage remaining in the cup, pulls down the spindle, closes the air inlet port, and the ejector begins to fill again. This process goes on continually, and perfectly automatically, so long as there is any sewage to eject and compressed air to eject it. It works at any speed, according to the time the sewage takes to fill it and to the amount of air-compression working it.

The advantages gained by the use of these ejectors are thus stated by their promoters:—

First. Small sewers at good inclinations, at no great depth, mostly above the subsoil water-level, discharging the sewage into an ejector, where it becomes effectually trapped.

Second. The rapid transit of sewage into an ejector before decomposition sets in.

Third. Reduced cost for flushing, on account of having smaller sewers.

Fourth. Freedom from bad smells emanating from manholes; for the cubic capacity of the sewers being small, the volume of air in contact with sewage is proportionately small.

Fifth. Less risk of spreading contagious diseases, as each drainage district is independent of another.

Sixth. Facility for extension, irrespective of levels.

On the other hand, we have to set—

First. The annual cost of working. This must undoubtedly be greater than for a pure gravitation system, though no doubt it compares favourably with any systems in which all the sewage is collected at one point, and pumped from a greater depth than would be the case if it were intercepted in several places, as is done with Shone's ejectors.

Second. The loss of power due to the use of compressed air, such as the heat generated during compression, and which passes away without doing useful work; and the leakage and friction in the engines and mains conveying the power to the ejectors.

With regard to the first of these objections,—what is really the exact cost of lifting sewage by ejectors is not generally known, no details having ever, to my knowledge, been published. It is stated, however, in a paper read last year before the Society of Engineers by Mr. Ault (Mr. Shone's partner), that the usual effect obtained from the ejector when using air at a pressure of 11 lbs. per square inch is 58 per cent. of the I.H.P. of the driving engine (in this case an Atkinson gas-engine).

The η of a good centrifugal pump is about ...	52 per cent.
„ „ „ direct-acting steam-pump for water is about	88 per cent.

An average η for a good direct-acting steam sewage pump would probably be about 66 per cent., so that where pumping is necessary the ejector appears to be a little less economical than a steam-pump. Of course, also, where a system depends on gravitation only, and the sewers are so flat as to be sewers of deposit, a great set-off to the expense of ejection is the reduction in cost of cleansing the sewers, and their improved sanitary condition consequent upon better gradients.

With regard to the second objection—

The estimated loss due to compression (isothermal) is about	31 per cent.
The estimated loss due to leakage and friction in engines, mains, and ejectors ...	11 per cent.
Total	42 per cent.

This loss, however, compares favourably with that in other classes of pumps; and it has been found that when the air is not compressed to more than 40 lbs. per square inch, the leakage and friction in the mains is not so large as to form a serious item of loss.

A great deal has been claimed by Mr. Shone for his system which in reality is not due to it, but is held in common by all good gravitation separate systems; such as the first three advantages I have stated. This has raised prejudice against his apparatus; but there is no doubt that under certain conditions, when it is impossible to obtain self-cleansing sewers by gravitation only, it is most useful, and in some cases even economical.

CONCENTRATION.

There is another point in favour of Shone's system of numerous ejectors, in that it is not necessary to collect the sewage at one point. Concentration may be both an evil and an advantage; but I fear that in most cases it is the former.

The present experience with the drainage of London, which is emptied into the Thames at two points, Barking and Crossness, is an illustration of the trouble caused by the accumulation at one point of large quantities of putrefying matter. The trouble of dealing with sewage so as to prevent a nuisance is at all times great enough; but it becomes doubly great where one district is made the receptacle for the refuse matter of many others. It may of course be claimed that the other districts are the better off in consequence—and so they may be, provided the sewers do not take upon themselves the vocation of ventilating flues, to draw the foul gases from the scape-goat district into those of its more fortunate brethren; but I am of opinion that trouble would often be saved, even if the establishment charges were rather higher, if sewage could be delivered and dealt with at several points instead of at one.

The city of Berlin, with its population of over 1,000,000, disposes of its sewage by pumping it over several farms near Berlin; and, in a letter recently written by the Chairman of the Sewage Committee, does so without complaint and at a profit.

VENTILATION.

One of the most vexed points of late years with regard to all water-carriage systems is that of ventilation.

1. Whether it is absolutely necessary.
2. How it is to be accomplished.

At present the pro-ventilationists undoubtedly hold the field, though there are some notable and successful exceptions, such as Bristol, to the general rule. Mr. B. Latham an authority on sewerage, lays it down that all sewers must be ventilated by free communication with the outside air. This rule has been generally followed; but —partly on account of the fault previously mentioned, of sewers so flat that they are sewers of deposit, and partly, no doubt, through bad workmanship, which causes accumulation of decomposing matter—these ventilators have been a continual bugbear to the public and a thorn in the flesh to the engineer.

That a systematic ventilation of sewers, by means of shafts communicating freely with the open air, is not absolutely a necessity, is proved by their non-use in Bristol, and the city's excessively low death-rate.

It is not of course likely that the Bristol sewers are absolutely without any air currents; but the internal and external air have not designedly any free communication.

In providing ventilators, the necessity for the presence of gas in sewers is taken for granted; but sewer gas being the product of decomposing matter, it follows that the more quickly such decomposing matter is taken away, the less will sewer gas be formed. Ventilation is therefore clearly dependent on the construction of the sewer. A sewer badly constructed, so that sewage is obstructed in its free passage, will have more sewer gas in it than one in which the obstructions are reduced to a minimum. Hence the utility of a perfectly smooth surface and of a small wetted perimeter.

Again, if a sewer be laid at so flat a gradient that there cannot be a self-cleansing velocity, an accumulation of foul matter must follow, and consequently an accumulation of sewer gas.

Flushing with large quantities of sewage or water has been requisitioned, to improve the velocity and to clear out the holes and corners where foul matter has collected, and with very great success; but it is chiefly because so many existing systems are faulty in these particulars that the accumulation of gas has been so troublesome. As it was impossible, except at great expense, to prevent the cause, the only way appeared to be to reduce the evil by so thoroughly diluting the foul sewer air with fresh air that the gas would be rendered harmless. It has, therefore, been the approved policy to place a free-air opening into the sewer at each manhole and lamphole; at first by placing gratings at the street surface, and latterly by erecting special shafts in which an artificial draught is induced, such as by a furnace or gas burners.

If a smell is complained of as coming through the manhole, the reply is, that the sewer air must be still further diluted by a larger number of openings. In all this the aim has been, not so much to eradicate the cause, as to minimize the evil effects.

In a paper read last year before the Sanitary Institute by Mr. J. S. Haldane, upon the Air of Sewers and Buildings, a great deal of new light is thrown upon the effects of ventilation. He had been making a series of careful observations upon the amount of CO_2 and the number of micro-organisms contained, firstly, in the air of various domestic and public buildings, and secondly, in both ventilated and unventilated sewers, choosing for his example of the latter the sewers of Bristol.

In the first place, he brings out the fact that, though sewer air, in a ventilated sewer, contains about twice as much CO_2 per litre than does the outside air, it contains less micro-organisms. Secondly, that the air of a ventilated sewer contains four or five times as many micro-organisms as an unventilated sewer, and that the amount of CO_2 in the unventilated sewer was surprisingly small as compared with what the subsoil air at the same depth probably contained.

From these observations he remarks: "I think there is a strong case from the sewer point of view against outside air. It is evidently, as a rule, the outside air which contaminates the sewer air with micro-organisms, and not the other way. The results of these researches will perhaps tend to mitigate some of the terror with which we have come to regard sewer air. Sewer air has commonly been supposed to be "loaded" with micro-organisms, whereas it turns out to be, in reality, some of the freest air from micro-organisms that can be found."

We do not yet fully understand the functions of the various micro-organisms found in air and water, so that we cannot yet tell whether a large number of micro-organisms per litre shows the air to have been injuriously polluted.

The above remarks and experiments, however, seem to point in the direction of avoiding the free ventilation of sewers by contact with currents of fresh air. Apparently the erection of simple vents to prevent any undue pressure of sewer gas—should such be found—ought to be quite sufficient; or if, instead of the present open ventilators, openings were formed in the top of sewers communicating only with the subsoil, an inexpensive vent would be provided, without having to pollute the air we breathe.

Objection might be raised to this suggestion, that the ground air would be polluted, and the polluted air would be sucked up by the heat of fires, etc., into the houses. But care is of course implied, in forming free openings into the sewers in whatever mode they are constructed, and the same would apply to this. Sewer gas is chiefly composed of carbonic acid gas, sulphuretted hydrogen, and ammonia. The former, which is much heavier than air, already exists in the subsoil to ten times the amount, and the two latter are lighter than air, and will rise; but in rising through the subsoil they will have ample opportunity of filtration and dilution before they reach the surface. In addition—given a properly constructed sewer—the amount of sewer gas is comparatively small, and much of the gas will remain in the sewer.

With these remarks, I would leave my subject. Although so much has been accomplished during the last half-century, it clearly cannot by any means be claimed that we have yet arrived at perfection in our systems of sewerage.

Our views are continually altering with experience, so that methods that were popular a few years ago are almost discarded now, and we lay them down to grasp improved ones.

I have therefore endeavoured to describe the practice of the present day, with the steps that have led to it, and to indicate the points from which it appears to me fresh departures may be made toward that perfection which is the *ultima thule* of every branch of engineering.

Birds Exhibited at Meetings.

GREAT GREY SHRIKE (*Lanius Excubitor*) was shot at Abbot's Leigh in December, 1888. This species, which has its home in the north of France and in Germany, is a frequent visitor to the Eastern Counties, but occurs only as a rare straggler in the West. The two other specimens shown were both shot at Clevedon; one in the autumn of 1888, and one in the previous year.

PALLAS' SAND GROUSE (*Syrrhaptes paradoxus*). Out of the large numbers of this singular bird which have visited this country during 1888, only four occurred in our district, one at Yate and two at Hambrook (Glouc.), and one at Ken Moor, near Yatton (Somt.). It is twenty-five years since an irruption of this species occurred in this country (in 1863), when a great many were obtained in various counties, but none in our vicinity. All four specimens were shot during the month of July.

PUFFIN (*Mormon fratercula*). This bird, evidently quite a young one, was caught at Cheddar, driven inland by some accident. It was probably a straggler from Lundy Island, where this species breeds.

The BELL BIRD (*Chasmarhynchus carunculatus*), from Demerara. This singular bird is remarkable for its note, which resembles the tolling of a bell, and also for the curious appendage growing from the base of the bill, in the shape of a fleshy horn, 2 or 2½ inches in length, which hangs alongside of the bill when the bird is at rest, but stands erect when the bird is excited. The use or purpose of this extraordinary organ remains quite unexplained.

On the Perceptions of Animals.

By Prof. C. LLOYD MORGAN.

Read March 7th, 1889.

Abstract.

THIS paper was in continuation of a previous communication on senses and sense organs. Some account was given of the psychology of perception, and of the distinction between perception and conception. The main distinction was found to lie in the fact that conceptual processes involved analysis. It was held that there was no evidence to justify us in supposing that the brutes are capable of analysing the phenomena of nature. Their mental operations are probably confined within the sphere of perception.

Defining inference as the passing of the mind from something immediately given to something not given, but suggested through association and experience, three stages of inference were marked out: (1) habitual inference on immediate perception; (2) intelligent inference in the perceptual sphere; and (3), rational inference, implying analysis (conceptual). The inferences of animals were habitual and intelligent, but not rational.

Before taking leave of the subject, the writer was anxious

that it should not be thought that, in contending that intelligence was not reason, he wished in any way to disparage intelligence—nine-tenths of the actions of average men were intelligent but not rational. There were hundreds and thousands of practical men who were in the highest degree intelligent, but in whom the rational faculty was but little developed. Was it, he asked, any injustice to the brutes to contend that their inferences were of the same order as those of these excellent practical folk? In any case, no injustice was intended. If he denied them self-consciousness and reason, he granted to the higher animals perceptions of marvellous acuteness and intelligent inferences of wonderful accuracy and precision.

Notes on the Water-cells of the Camel's Stomach.

BY G. MUNRO SMITH, L.R.C.P. Lond., M.R.C.S.

Abstract of Paper read Jan. 3rd, 1889.

SINCE the time when Abraham's servant made his camels kneel down at the end of their day's journey, outside the city of Haran, every record of these animals speaks of them as being in a state of servitude. For thousands of years they have been the "beneficent ships of the desert," travelling with little food and less water over hot and dry sandy regions. We should, therefore, expect them to be specially qualified for this kind of work, and that their natural qualifications would be improved by long custom. We find the former, at all events, to be the case; their feet are broad and well-fitted for walking on shifting ground. They are wonderfully hardy, bearing fatigue well, and requiring only the commonest vegetable food; their eyes are protected by the prominent overhanging eyebrows from the glare of the sun; they have in their humps a store of fat which they can use as a reserve fund during their enforced periods of abstinence; and they have, as the specimen shown illustrates, an arrangement by which water may be stored up in their stomachs.

This last peculiarity has, however, been denied. Professor Macalister says: "The *second* stomach of the camel has deep cells or compartments, which has given origin to the fable about the capacity of camels to store water in their stomachs."

Professor Huxley, however, in his "Anatomy of Vertebrated Animals," writes as follows: "The œsophagus opens directly into the *paunch*, which is lined by a smooth, not papillose epithelial coat. From its walls at least two sets of diverticula with comparatively narrow mouths are developed. These, the so-called *water-cells*, serve to strain off from the contents of the paunch *and to retain in store a considerable quantity of water*." This account seems quite accurate; it is the *first*, not the *second*, stomach which has these cavities in its walls, and it is certainly not a fable that water can be drained off into them. Whether they have been developed in the process of evolution to fit the animal for its long periods of drought, or whether they serve some other purpose, I cannot say; but the first hypothesis seems to me quite reasonable.

There is abundant evidence of the power of the camel to go for a long time without water whilst doing hard work. Pliny remarks that they can go four days together without drink (without apparent suffering); Burckhardt and other travellers also bear witness to this.

Professor Owen, in his "Comparative Anatomy and Physiology of Vertebrates," gives a clear description of these cells, with a good illustration, and is of the opinion that they can retain water, "as in a reservoir, for some days."

The specimen shown was taken from a camel that was killed at the Zoological Gardens. The paunch was found to be enormously distended with food, and these cavities—of which there must have been fifty or sixty—contained a grumous fluid. The stomach wall was from two to three inches thick in some parts, rather thinner in others; and the orifices of the water-cells were constricted, forming a kind of sphincter. The lining epithelium was smooth. Microscopically, the muscular coat consisted of masses of long, unstriped muscular fibres, with indistinct nuclei.

Suggestions as to the Causes of the Difference in the Colour between the Flowers and Foliage of Tropical and of Temperate Regions.

By CHARLES JECKS.

Read December 6th, 1888.

MR. WALLACE has stated, in his "Malay Archipelago," that the colour of the flowers, and by implication that of the foliage, generally is not so brilliant in tropical as in temperate climates. Now it is true that these statements are quite at variance with those generally believed concerning the flora of tropical climates; but coming from the source they do, we can scarcely, I think, dispute their accuracy. Indeed, if the question be examined, the result will, I think, be found, in accordance with the above assertion, as only what might naturally be expected under tropical conditions.

The idea of brilliant colour appertaining especially to tropical flowers seems, Mr. Wallace remarks, to have arisen partly from the fact that in this country tropical plants are generally grown in conservatories, where they are perhaps exposed to abnormal conditions of light, and also that our tropical plants are collected from regions widely separated from each other.

It would indeed seem that while the tropical regions are far richer in the production of vegetable forms, so far as regards brilliancy of colour we have the advantage ; that is, the vegetation of temperate is more brilliant in hue than that of tropical regions. As probable causes for this state of things in tropical climates may be assigned greater general richness of soil and amount of moisture in the air, as opposed to the generally poorer soil and drier atmosphere, together perhaps with the greater amount of sunlight, in temperate regions. In our own climate, for instance, under the conditions of a clear blue sky, plenty of sunlight, a light soil and a dry season, the colour of the flowers is naturally more brilliant than it is under conditions of an opposite character.

The perhaps greater number of brilliant coloured flowers in our climate may be in part accounted for by the visits of insects to different flowers; for whenever a flower shows any tendency to vary in the direction of brilliancy of colour, it is probably visited by them, and its propagation ensured by the transmission of the pollen to another plant, the tendency to brilliancy of colour being increased by heredity, and further confirmed by suitable conditions of growth, etc. In connection with this subject, the question suggests itself: Do cultivated plants come under the same law as wild animals in a state of confinement ?

We know that in some cases wild animals are not so fertile in confinement as when free, and it would seem that a certain degree of change is thus produced in the generative organs inducing partial sterility ; there seems also some reason to believe that, as a plant tends to vary, so does it suffer in its fertility. The cultivation of plants often produces variation, and this probably often means with such plants an increase in brilliancy of colour in the flowers, which would thus seem to be at least correlated with the tendency to infertility above-noted.

The same suggestions as to infertility may, I think, be applied to wild flowers growing on different soils and under different conditions; but here the tendency to decrease infertility may perhaps be in some measure counteracted by the intercrossing of different species by the visits of insects.

Coming now to foliage, I think that we shall find the conditions above-named as probably affecting the colour of flowers have here also had a proportionate effect, the foliage of tropical climates being generally of a deeper hue than that of temperate regions. Indeed, the farther we recede from both tropics, north and south, the more as a general rule do we find this to be the case, the more does the lighter hue predominate.

The causes which tend to produce this difference of hue in the foliage are then, I believe, much the same as in the case of flowers. The comparative absence of sunlight, a warm, damp atmosphere, and a comparatively rich soil, tend to produce a deeper hue in both foliage and flowers, as an abundance of sunlight, a cool, dry atmosphere, and a comparatively poor soil are more favourable to a brighter colour.

In conclusion, taking it for granted that we have good reason for believing that in tropical regions a brilliant colour in flowers and a light hue in foliage is the exception, and the reverse the rule, while in more temperate regions a more brilliant hue in flowers and a lighter one in foliage is the rule, and the reverse the exception, I trust that I have been able to throw a little light upon the possible causes of these phenomena.

The Warehousing of Grain.

By JOHN M. McCURRICH, M.A., A.M.I.C.E.

Read before the Engin. Sect., March 19, 1889.

AS this country is deriving, in an increasing degree, its supplies of grain from abroad, the question of the best methods for its removal from ships and its storage in granaries is one of great importance. The following tables show how the importation of grain and flour is increasing:—

QUANTITIES OF GRAIN AND FLOUR IMPORTED INTO THE UNITED KINGDOM IN CWTS.

	Average of two years, 1867–1868.	Average of five years, 1883–1887.	Increase per cent.
Wheat	33,642,669	55,236,395	64
Barley	6,580,723	14,546,741	121
Oats	8,759,849	13,812,954	58
Maize	10,006,327	13,045,049	30
Other kinds	4,085,807	5,809,284	42
Flour of Wheat	3,342,995	16,002,050	380
Flour of other kinds	92,615	828,103	794

Taking the average of the quantity of wheat imported for the years 1883–1887, and calling the amount from the United States 100, India would be represented by 40, Russia by 31, Canada by 9, and Chili and Germany by about 7 each.

During the same years the average amount of grain that came to the principal ports was as follows, the amount being in cwts.:—

	Wheat.	Barley.	Oats.	Maize.	Total.
London . .	11,461,026	2,197,124	9,331,458	3,533,321	26,522,929
Liverpool .	15,895,198	339,944	168,960	8,329,874	24,733,476
Hull . . .	5,472,641	1,660,386	742,036	1,600,892	9,475,955
Bristol . .	3,301,954	3,190,517	191,600	2,028,898	8,712,969

Glasgow comes next with a total of a little over five millions, and Dublin and Leith follow with about 3¾ millions each. It will be seen that Bristol stands far ahead of any other port as regards barley.

Grain chiefly comes in bulk; but from India, Australia, South America, and California it comes in sacks.

Until a comparatively recent date, the usual way of getting grain into a grain warehouse or granary, was by men carrying the grain in sacks to a hoist or jigger, by means of which it was raised to the various floors. The same method was usually adopted to get it out of the building, but sometimes the sacks were slid down inclined shoots. It was, however, found that, where large quantities of grain had to be dealt with, such a process was both slow and costly.

Somewhat over twenty years ago, when the design of the two large grain warehouses at Liverpool and Birkenhead was under consideration, great attention was directed towards ascertaining the best means of conveying the grain horizontally from one part of the warehouse to another, and for that purpose a number of interesting experiments were made. The following particulars regarding the Liverpool warehouses are mostly taken from a paper read to the Institution of Mechanical Engineers by Mr. Westmacott, of Sir W. Armstrong & Co.

The first trials were made with a revolving screw, 12 inches diameter and 4 inches pitch, made in lengths of about 12 feet from bearing to bearing, the space between the screw and the fixed casing in which it revolved being $\frac{1}{4}$ inch. At 60 revolutions per minute, which was found to be the maximum effective speed, the screw discharged the grain at the rate of $6\frac{3}{4}$ tons per hour, and required 0·04 horse power for every foot run. The sectional area of the body of grain propelled was 49 per cent. of the whole transverse area of the screw. Subsequent experiments were made with screws contained in revolving casings. A 12-inch screw constructed in that way when driven at 36 revolutions per minute, delivered 10 tons of wheat per hour. When driven at a high rate of speed, the grain was simply carried round and not propelled forward at all. The best results were obtained with a pitch of $\frac{2}{5}$ths of the diameter. However, the great power required to drive screws with revolving casings proved an insuperable objection to their use.

Bands made of canvas were then tried, and afterwards bands made of india-rubber and canvas. It was found that for light grain 8 feet per second was the maximum speed, and that for heavy grain about 9 feet was the maximum. With 12-inch bands 35 tons per hour could be carried, and with 18-inch bands a maximum of 70 tons per hour was obtained. Comparing the amount of power required to convey a stream of grain at the rate of 50 tons per hour through a distance of 100 feet by means of the common screw in stationary casing, the tubular screw with revolving casing, and the travelling band 18 inches wide, the following results were obtained:—

With the common screw	18·38 h.p.
„ tubular „	25·00 „
„ 18-inch travelling band . .	1·02 „

The great superiority of the band over the screw as regards economy of power, was thus clearly shown. The band was also shown to have another important advantage. When the screw was used, injury was done to the grain by the revolving blades; but the grain, when carried by bands, sustained no such injury.

To get grain from the vessels into the warehouse, it is raised out of the ship's hold to the top of the building by means of cranes and bucket elevators, taking about a ton at each lift, and it is then discharged into hoppers, weighed, and, by a system of horizontal bands and vertical shoots, conveyed to various parts of the building. Portable cup and band elevators are now also used for the same purpose.

The two grain warehouses referred to belong to the Mersey Dock Board, and were designed by Mr. Lyster, the Docks Engineer. Both buildings are of great capacity. The one at Waterloo Dock has a floor area available for the storage of grain of 48,918 yards, which, at four quarters per yard, would give a storage capacity of 196,000 quarters. The other, at the Great Float, Birkenhead, has a storage capacity of about an equal amount. At the Birkenhead granaries there are in addition 46 silos, each 6 feet square and 40 feet in height. Each of these silos is fitted with a central air funnel, 16 inches in diameter, made of perforated sheet iron. Air is forced up these funnels by means of fans, and, escaping through the perforations, it thoroughly ventilates the grain. These silos are used for grain which arrives in bad condition. All the machinery of these warehouses is worked by hydraulic power.

In the United States of America, bands, or belts as they are called there, are greatly used. At Duluth there are a number of large granaries, and belts are used on a more extensive scale than at any other place. One of the belts travels 11 feet a second, and carries about 330 tons per hour. It is a combination of band and bag. At the sides there are india-rubber belts 7 inches wide, with a piece of canvas between them, the total width being 3 feet. The canvas bags down 4½ inches in the centre, the amount being regulated by curved iron cross-bars, 1¼ inches by ¼ inch, rivetted every 4 feet between the rubber edges. Another belt has a still greater capacity, and travels at the rate of 13 feet per second.

At London, the chief centres for the importation of grain are the Millwall Docks and the Surrey Commercial Docks. At the former as much as 35,000 quarters have been unloaded in one day. There are several features of interest in connection with the unloading and storage of grain at the Millwall Docks, some of the systems adopted being found nowhere else. Special railway trucks have been made for the storage and delivery of grain, each truck holding about 100 quarters, equal to somewhat over 20 tons of wheat. They are made without springs, and cost about £50 each; about 1,000 have been provided. The grain is raised from the ship's hold by tubs, which are filled by men with light iron buckets called "bushels." The tub holds five quarters fully, and the author noted the time that five men took to fill one, and found that it was about one minute on an average. The tubs are raised by cranes and landed on the tops of "bins." The outer rim rests upon supports, and the bottom of the tub, which is supported by the crane chain, falls a short distance by gravitation and allows the grain to escape into a large hopper on the top of the "bin." In the bottom of the hopper there are a number of shoots with slide valves, and under these are a number of small weighing machines which are attended by a weigher. These machines are of the most simple description of balance scale, there being a hopper at one end of the lever and weights corresponding to the weight of a sack at the other. Whenever the weigher sees the balance tilt up, he shoves in the slide valve and then allows the grain to fall down a shoot, by which it is discharged into an opening at the top of one of the special railway trucks. When a number of trucks have been filled in this manner, they are taken and stored under sheds which cover about five acres. These trucks have four slide-valves in each side, and they can be placed at such a level as to allow the grain to flow into sacks standing on weighing machines, be weighed, and then wheeled into ordinary railway trucks standing alongside at a lower level. It is claimed for this system that it is extremely convenient for grain merchants, and that it is very economical. However, the first cost is high and the extent of ground is so great as, at most docks, to prevent the system being adopted, even were it considered desirable. These covered trucks are also used for conveying grain to a granary situated some distance from the Dock. The trucks are run close alongside the granary, the slides are pulled up, and the grain falls into an elevator pit, from which it is raised by the elevator to the top of the building. The granary is about 160 feet long by 80 feet wide, and is divided into four fireproof compartments by vertical walls, there being an elevator to each compartment. The elevators are carried considerably higher than the building, and there are two inclined shoots from each elevator, each shoot discharging into a large bin and serving an area of 40 feet by 40 feet. A number of shoots lead from each bin; these are for some distance radiating and inclined, and then they are carried vertically downwards to the bottom of the building. Grain is thus got easily to any part of the various floors. When it is taken out of the building, it is sent down to the lowest or sunk floor, where it is weighed. The system is in many respects simple, there being no band conveyers. However, the grain has to be raised to a greater height on that account, and double the number of elevators have to be provided than would be required were bands used.

Another peculiarity about the Millwall Docks is the system of jetties in the dock. A large proportion of the grain goes from the dock in barges to warehouses situated up the river, and these jetties are used for that class of traffic. A vessel is brought alongside the jetty, on which are placed two or three cranes and several high bins similar to those already described, and the grain is lifted, weighed, and landed in the barges in a similar manner.

Priestman grab buckets are also used instead of the tubs. Raising grain in that way, when it can be worked to advantage, only costs about one-half of what it costs by the latter system; but in a great many cases it cannot be applied to full advantage. Grain often comes in small "parcels," and hand-filling has therefore to be resorted to.

Close to the Millwall Docks, but on the other side of the river, are the Surrey Commercial Docks, where there are several large granaries. The one last erected is about 260 feet long by about 100 feet wide. There are three elevators, one being situated close to each end of the building, and one in the middle. In front, between the building and the quay, are two lines of rails. On the front line are placed 30 cwt. hydraulic cranes, and on the back line, one fixed and two movable hoppers or bins. The cranes are fitted with Priestman grab buckets, and raise the grain from the hold and deposit it in the hoppers, where it is weighed in quantities of about two tons at a time, and it is then discharged by openings in the granary wall into a tunnel which runs parallel to the quay. The elevators raise it to the top of the building, and it is distributed by bands and shoots. The bands are 22 inches wide. The best work is done by the cranes when grain has to be discharged out of barges. The greatest amount done has been the raising of 600 quarters of wheat, or 133 tons per hour, by means of one crane. The 22-inch band carried that amount easily, and it is considered that 150 tons could be carried with safety. Three sizes of buckets are used, which, in the case of wheat, hold 13, 17, and 20 cwt. respectively. On one occasion, when the 17 cwt. bucket was used, it was found that the crane made 125 lifts in one hour, the average lift being about 30 feet, and the range of slewing being about 90 degrees. In working from a ship the ordinary speed may be taken at from 70 to 90 lifts per hour ; but the amount of grain discharged varies, a good deal depending on size of hatchway, the trouble there may be with shifting boards, etc. The average may be taken at from 60 to 80 tons per hour to each crane.

Floating elevators are also used, more especially at Liverpool, for getting grain out of vessels. The driving machinery is placed upon a barge, and the elevator is movable ; but when in position for working, it is fixed over the hatchway of the vessel. The grain is raised ; and, by means of lengths of travelling bands, which are usually suspended from the roof of the shed, it is conveyed to the shed or warehouse within a distance of from 70 to 80 feet from the vessel. One great advantage of this system is that no machinery is required in the sheds to which it is applied. It is best adapted for buildings with one or at most two floors.

Various types of floating elevators are in use. One, Gillet's patent, has been at work successfully for some years at Dunkirk in France. The capacity is 50 tons per hour, and the machinery is fixed in a tower erected on a barge. It consists of two bucket elevators or ladders suspended on a universal joint, from the outer end of a steel girder of inverted U section, the inner end of the girder being hinged on a shaft, which traverses a curved roller path from back to front of the tower. The girder carries a band, which is driven by a pulley at the centre of the curve. The outside elevators are driven by this band, and have a vertical range to suit the varying draught of the ship. The girder and elevator may be moved horizontally and vertically, while the machine is at work, being under the control of one man upon the deck; and when out of use, it may be run back and housed inside the Tower. The grain is brought into the Tower by the band, and is then passed through an automatic weighing machine, and delivered into the bottom of an ordinary elevator, which raises it to the roof, so that it may be delivered direct to barges or into warehouse.

The grain warehouses which I have described are all "floor granaries," the grain being stored on the floors usually to a depth of about 5 feet. In this country preference is given to that system. In America, on the other hand, the "silo" system is universally adopted. In Spain and some other countries grain was, and still is, stored in pits dug in the ground called "silos"; and the term has been transferred to hollow-covered shafts built above the ground for the reception of grain. Large granaries constructed on that system have been erected at Bootle, Liverpool, and at Fleetwood, and on the Continent the system is largely adopted. Perhaps the finest examples are to be found in the large granaries lately erected by the Roumanian Government, which are provided with the finest collection of weighing machines, the author believes, anywhere to be found. The grain stores attached to the best modern mills erected in this country are now usually built on the "silo" principle; but it must be remembered that, in the case of mills, the grain is usually stored only for a short time.

The shafts are constructed in a variety of forms, but the square and the hexagon are the most common. Theoretically the latter requires a less amount of materials; but the saving is often more than counterbalanced by the increased cost of construction. Brick and wood are the materials usually employed. Wood is, of course, inflammable; but, on the other hand, it is light, is a bad conductor of heat, and is capable of absorbing moisture from the grain. A combination of flat iron rings and concrete is also used. The silos are usually made from 12 to 14 feet square and 30 to 50 feet high. The base is made of pyramid form, for convenience of discharging the grain.

The chief advantages claimed for the "silo" system are that all the space is used, as the silos can be completely filled with grain; that they can be cheaply and readily filled and discharged, and that no turning of the grain by manual labour is necessary.

The chief claims urged on behalf of "floor" granaries are somewhat as follows: The grain is kept in good condition by means of the stream of air which passes over it from the windows and doors on opposite sides of the building, there being usually a space of from 3 to 4 feet between the grain and the floor above. The grain can be readily inspected from time to time, and samples can be taken. Where grain arrives in bad condition, it can be spread thinly over the floor, and after being thus exposed for some time, and turned over once or twice, it is brought into good condition. When grain comes in a good state, it may be stored for a couple of years without requiring turning over, but it is necessary to carefully examine it from time to time. In this country grain comes from such long distances by sea that it often arrives in a somewhat bad state. That fact, coupled with the varieties of grain imported here, render the conditions different from those in America and on the Continent.

It is generally believed in this country that grain, if not injured, is at least not benefited by being stored to great depths, and for some classes of grain, such as soft wheat, the system of storage in silos is considered by some authorities to be unsuitable. Where grain arrives in bad condition, it is often refused, but, if put into a silo, it sometimes cakes, and will not run out. The usual method of bringing such grain into condition is to shift it from silo to silo by means of the bands and elevators. Difficulty used to be experienced in turning out a good sample, the heavier grain going to the middle, and being drawn off first; but, by the use of mixers, that difficulty has now been overcome. As regards the advantage in the case of silos, owing to their being capable of being completely filled, the gain is not usually so great as at first sight it would appear. Owing to small "parcels," and grain being drawn off from time to time, many of the silos are only partially filled. Much may be said on both sides. It, however, appears to the author that in some cases it would be advantageous to adopt the "silo" principle, while in other cases it would be preferable to store on floors.

Having described generally various methods of warehousing grain, it will be well now to enter more fully into a particular case, and for that purpose the author has taken the new granary lately erected at Prince's Wharf.

Owing to the limited extent of the site and the nature of the approaches, it was a work of much difficulty to design a building that would suit the various requirements, which were as follows:—

(*a*) To load from a vessel (1) into the granary either in bulk or in sacks, (2) into railway trucks, (3) into road waggons.

(*b*) To distribute the grain readily to the various floors of the building.

(*c*) To get the grain easily from the various floors to the ground floor, weigh it, and get it loaded easily into railway trucks, road waggons, or small vessels.

Various plans were made out, showing arrangements adapted for discharging vessels by cranes or elevators, but it was found that, by the custom of the port, it was necessary to weigh the grain on deck, and therefore it was not possible to adopt any of those mechanical appliances for discharging from the vessels.

The building is 232 feet 6 inches long by 99 feet wide, the width being determined by the extent of ground belonging to the Corporation. There is a line of rails in front for both broad and narrow gauge trucks, with a verandah over it. At the back of the building there is another line of rails. Inside the building there are two lines of rails at front and back, and a centre hauling-way, 25 feet wide, with six cross-roads to the quay, and recesses at the back portion of the building for loading carts. There is a cross-line of railway inside the building with four turn-tables, the traffic being worked by hydraulic capstans. The roof is in four spans, and the space between the queen-posts is made use of for the longitudinal bands. At the middle of its length the roof is constructed so as to provide accommodation for the transverse bands. Under that floor, which is called the machinery floor, are the grain floors, seven in number. Six of these are constructed of timber, and the seventh, or lowest, is a fireproof floor, constructed with iron girders and cement concrete arching. Under that floor are the weighing platforms, which are constructed at a height above the ground-floor convenient for loading into trucks or carts. The building is divided into two by a strong vertical brick wall, reaching from the fireproof floor to a height of about 5 feet above the roof. The staircase is inside the building at the back, and is fireproof.

Between the granary and the quay wall there is a tunnel with arched roof, 8 feet 3 inches wide, and 280 feet long. It is lined with white-glazed bricks. At intervals of about 13 feet there are cast-iron shoots from the quay through the roof of the tunnel. These shoots have a swivelling part at the lower end, so that they can be used for either band. The covers are flush with the quay, and are watertight.

The operation of getting grain into the building in bulk is as follows: The grain is raised in sacks out of the ship's hold by hand-winches, or in case of a steamer, by the vessel's steam-winches. It is then weighed by hand-scales on deck. One gang of seven men can raise, weigh, and discharge about ten tons of wheat per hour, and six or seven gangs can work on to one band. The sacks are emptied into a movable wooden shoot, one end of which rests upon the ship's rail, and the other on a hopper placed over one of the shoots leading from the quay to the tunnel. It goes down that shoot into a travelling feed-hopper, from which it flows on to the centre of one of the hands. It is then carried at the rate of about 500 feet per minute to opposite the elevators, and by means of a "throw-off" apparatus is discharged into a shoot which leads to the elevator "boot." A "cup and band" elevator raises it to the top of the building. After passing over the pully at the top, which is 3 feet in diameter, the grain is discharged on to a cross-band, from which it is thrown off on to a longitudinal band, and then it passes down a vertical shoot by which it is conveyed to one of the floors. Under the joists of each floor the shoot has a cast-iron swivelling part in which a radial spout can be fixed, by means of which the grain can be distributed over a wider area. There are thirty-two of these vertical shoots, and each floor is thus divided into convenient areas for loading or discharging. Movable bulk boards are used for confining the different parcels of grain. Immediately above the level of each floor there is a slide-valve, which is used when it is wished to get grain out of the building. The slide-valve is raised, and grain is admitted into the shoot, by which it is conveyed to weighing-machines, which travel on rails fixed under the fire-proof floor. The weighing-machines are made by Reuther & Reisert, of Germany, and are automatic in their action, and weigh one sack at a time. They are capable of weighing three sacks per minute, which in the case of wheat would amount to about 20 tons per hour. These machines are extremely accurate when kept to one class of grain, but some difficulty is experienced in getting the same degree of accuracy when changing from one kind of grain to another. After being weighed, the sacks are taken on hand-trucks to the edge of the platform, and then put into railway trucks or carts.

In the case of grain arriving in sacks, such as cargoes of Indian corn, the sacks can be raised by jiggers fixed over each of the upper doorways, at front and back. There are eight of these jiggers, and they can be used either for raising or lowering sacks.

The whole of the machinery is worked by hydraulic power, the pumping station being at Underfall Yard, Cumberland Basin. Power is also obtained from that station for working the gates, sluices, and swing bridges at Cumberland Basin and Prince Street Bridge, and in the event of future increases of hydraulic plant, such as cranes, coal-tips, etc., the power will be got from the same place. There are three steel Lancashire boilers, 26 feet by 7 feet 6 inches diameter, a Green's fuel economizer, Brown's water softening apparatus, and two sets of compound surface condensing engines of the Worthington type. Each set can work to 200-pump horse power. There is an accumulator with a ram 20 inches diameter and 23 feet stroke. The main, which goes up Cumberland Road and along Prince Street Bridge Road, is seven inches internal diameter for a length of 1,920 yards, and it then branches into two five-inch pipes, one of which leads to the granary, and is 140 yards long, and the other goes across Prince Street bridgeway. The main is divided into sections by stop-valves, and there is a relief valve at the highest point. The pressure at the pumping station is 750 pounds per square inch, and, owing to the size of the main, the pressure is little reduced at the granary, even when all the machines are in operation.

There are the following hydraulic machines: two engines in the tunnel, one to each pair of bands, each engine being arranged so as to work one or both bands; four engines on the machinery floor, each of which drives an elevator and a cross band; four engines also on the machinery floor, one to each longitudinal band; one engine for driving a fan for ventilating the tunnel; eight jiggers and two capstans.

All the hydraulic engines are Brotherhood's patent three-cylinder engines, and were made by the Hydraulic Engineering Company, Chester. The longitudinal bands are driven by large pullies, and each engine has a heavy fly-wheel, and governors are also being provided.

The jiggers or hoists consist of a cylinder and ram, 5 inches diameter and 8 feet 6 inches stroke, with sheaves multiplying ten times. They have two barrels, and are made so that while one wire rope is ascending the other is descending. These jiggers are examples of the best application of hydraulic power, a high efficiency being attained.

To obtain rotary motion by means of hydraulic pressure entails a considerable amount of waste, the efficiency of the hydraulic engines being only about 50 per cent. of the power supplied. Each of the band-engines indicates about four horse power, and each of the engines for driving an elevator and cross-band about 17 horse power. To raise 75 tons of grain per hour to the height required and convey it along a cross band takes about 12 horse power, without making any allowance for friction.

Were the machines at the granary in constant use, steam-power would be much cheaper, but being intermittent in their action, hydraulic power is more convenient and does away with shafting, driving belts, etc. In addition, steam power would require to have been taken from a distance, as there is no place near suitable for the erection of an engine or a boiler house. There are various objections to the use of gas engines, such as dust, space occupied, etc. In addition, they would not have been suitable for the capstans. Great objection would have been taken by the Insurance Companies, which would have charged an extra premium for the additional risk. With hydraulic pressure, on the other hand, the risk of fire is greatly diminished, as the pressure water can be used for the extinction of fires. In the event of fire the water would be pumped at a pressure of 125 pounds through the return pipe in the staircase, there being a hydrant on each landing.

The bands are 20 inches wide and are made of two-ply canvas and india-rubber. Each band is capable of conveying about 75 tons of grain per hour. The upper or loaded part of the bands runs on steel rollers fixed, in the case of those in the tunnel, 6 feet 9 inches apart, and the return or empty part which runs underneath is also supported by steel rollers fixed, however, 13 feet 6 inches apart. The rollers have cast-iron spindles tapered at the ends. The weight of a roller and spindle is between 14 and 15 pounds, which is almost exactly the weight of beech rollers used by Armstrong & Co. The usual practice, however, of that firm is to use varnished yellow pine rollers. The spindles are supported on bearings of white metal run into cast-iron brackets, and are fitted with iron lubricators with heavy iron covers. These brackets rest on cast-iron frames securely bolted to the floor and are connected together by angle irons, one on each side. The travelling feed hoppers and "throw-off" carriages run on these angle irons. The travelling feed-hoppers are provided with inclined rollers on each side of the band. Each band is provided with a tightening apparatus. In the machinery floor this is effected by means of a sheave with sliding carriage and weights moving between wrought iron guides. In the tunnel, as there is no room for weights hanging under the floor, a tightening screw is used instead. Bands are affected greatly, as regards extension or contraction, by the degree of moisture in the air. In damp weather the bands contract, and in dry weather they expand.

It is a matter of great importance that the rollers should revolve when the band is in motion, otherwise the roller gets worn flat where the band passes over it. To insure that being the case, the shape of the spindle is very important; it should be sufficiently blunt to prevent any tendency to jam. The rollers should be well balanced when in motion, and the bearings should be kept well lubricated.

Each of the elevators has two "legs," which at top and bottom are encased in steel, the intermediate part being made of wood. The elevator bands are made of American elevator leather belting, 20 inches wide, jointed with cement, and with copper rivets, and also stitched. The buckets, which are of steel, are fixed at intervals of about 18 inches by means of bolts. At the top and bottom of each elevator are sheaves 3 feet in diameter and 21 inches wide. The bottom sheave is supported on bearings, with adjustable slides for tightening the bands. The driving gear is at the top, the elevator being driven by the hydraulic engine by means of a link chain.

The building was erected from the designs and under the directions of Mr. John Ward Girdlestone, the Docks Engineer; and the grain machinery contract was carried out by Messrs. Spencer & Co., Bristol and Melksham.

In the foregoing paper the author has given a description of the principal methods employed for warehousing grain, and hopes that it may prove of interest to the Section.

The Eiffel Tower.

BY G. E. CRAWFORD.

Abstract of Paper read in the Physical and Chemical Section.

1. HEIGHT.

THE most conspicuous property of the Eiffel Tower is its height. Hence a glance at the heights of some of the tallest buildings in the world should be interesting. They are—

	Metres.	Yards.
Washington Obelisk	169	183
Cologne Cathedral	159	172
Rouen Cathedral	150	162
Great Pyramid	146	158
Strasburg Cathedral	142	154
St. Peter's, Rome	132	144
St. Paul's, London	128	139
Notre Dame, Paris	66	72
Monument, London	65	71
EIFFEL TOWER	300	325

N.B.—To convert metres roughly to yards, add one-twelfth: thus, 300 metres = (300 + 25) yards.

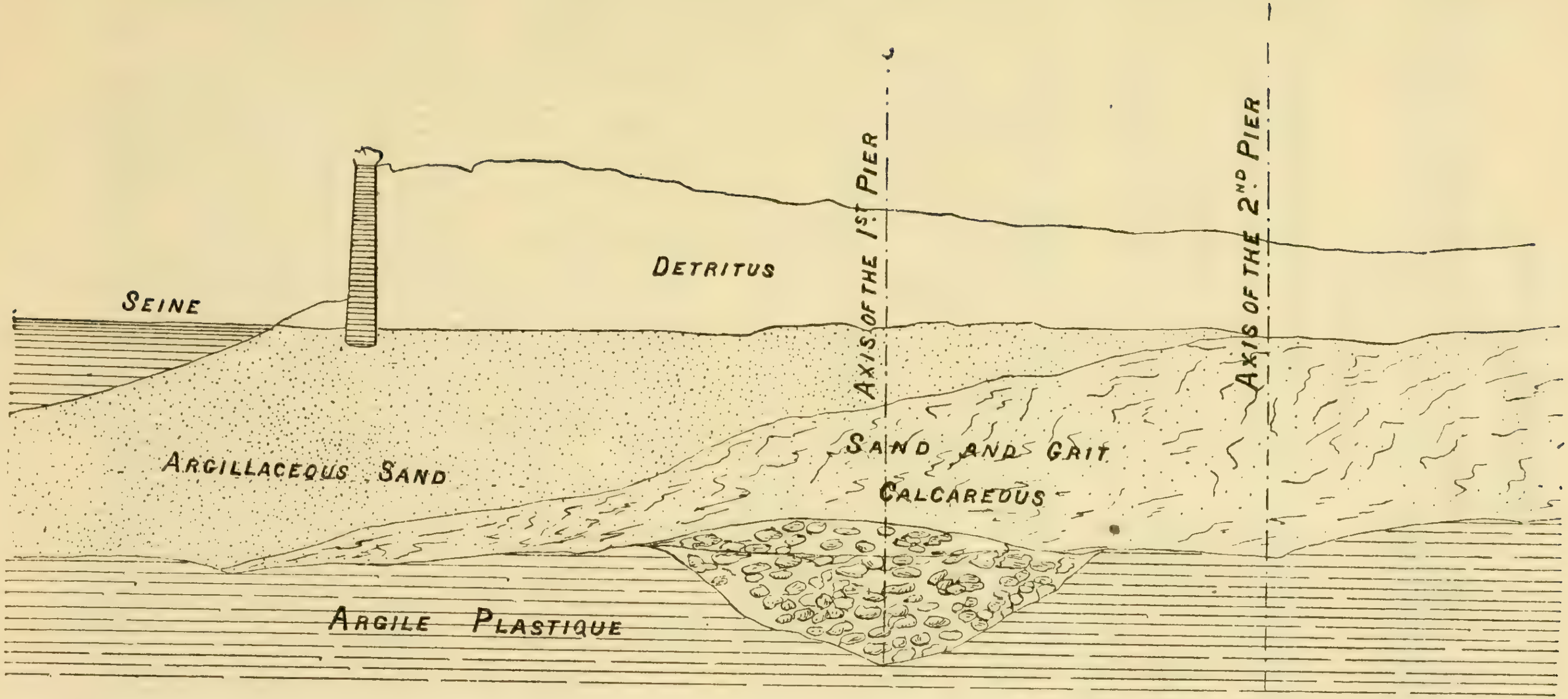

Seine
Detritus
Axis of the 1st Pier
Axis of the 2nd Pier
Argillaceous Sand
Sand and Grit
Calcareous
Argile Plastique

Fig. 1. SECTION OF THE FOUNDATION *river-side).*

Thus the tower is 325 yards, or 975 feet high, and a body would take over eight seconds in falling from its summit.

2. FOUNDATIONS.

The nature of the subsoil was satisfactory at two of the corners, those, namely, remote from the Seine (*Fig.* 1). But towards the river there was a tilt in the interfaces of the various beds, which required deep excavations and the use of caissons to fill up, before the foundations could be trusted.

The *argile plastique* has an average thickness of 16 metres, and rests on the chalk of the Paris basin. It can safely bear a load of from 40 to 50 pounds per square inch.

The foundations remote from the Seine offered little difficulty. They were filled up with concrete which dried as it was deposited. For the others, iron caissons worked by compressed air were sunk to a depth of 14 metres. The workmen inside dug away the loose damp earth which the caisson encountered in its descent, and as soon as a homogeneous surface was reached, filled up the vacant space with concrete to a height of seven metres. The system of caisson-foundations is expensive, but rapid and secure. It has been also used for the Forth Bridge, the Brooklyn Bridge, and the Magasins du Printemps in Paris.

The weight of the tower is 9,000,000 kilos, or 9,000 tons. (N.B.—English ton = French *tonne*, nearly = 1,000 kilos.)

The area of the concrete is such that when the above pressure is distributed over it, it only amounts to 30 pounds per square inch. Above the concrete rest stone piers, shaped like oblique pyramids, which bring the foundations level with the upper ground. The pressure on these, owing to the reduction in area, increases up to 420 pounds on the square inch, or only one-fortieth of the maximum load at which the stone (quarried at Château Laudon) has been found to crush.

3. Material.

The possible materials which present themselves for such a structure are

Wood, Stone,
Steel, Iron,

and a combination of stone around an iron framework.

Now, wood is too light to be safe in high winds; stone is very expensive, and heavier than metal in proportion to the height attained; further, no mortar yet discovered will stand more than 2,000 lbs. nominal, or say 200 lbs. working pressure per square inch; steel is too light, and, like wood, too elastic, so that in a wind the rocking would tend to dislocate the structure. Iron, which has none of these defects, being heavy, rigid, and homogeneous, is therefore indicated.

It may here be remarked that the chief utility of the tower lies in the fact that it gives us one more practical example of the capabilities of iron. The ancients long ago exhausted all the possibilities of stone. It remains yet to be seen what iron can do, a problem to which the Forth Bridge and Eiffel Tower are only partial solutions. It must be remembered that the strength of iron is not an inherent property, like the hardness of diamond or the suppleness of bamboo, but an acquired one. The ores of iron can be crushed to powder in the hand, or its nodules broken with a light hammer. Wrought iron and steel, by processes entirely artificial, have acquired the property of resisting enormous strains. Within only the last few years the efficiency of these processes has been vastly improved, and feats of engineering made possible which were hardly dreamed of before. It may be we have not seen the end of this improvement.

4. Shape and Stability.

In section the tower was bound to be a regular polygon. A circular shape, or many-angled polygon, seems the most symmetrical; but as each angle means one more ascending rib in the tower, economy of weight demands as few angles as possible. The triangle has of all plane figures the fewest angles, but such a section would have entailed great loss of room on the various platforms, because its angles are so sharp. A square was therefore the next to suggest itself.

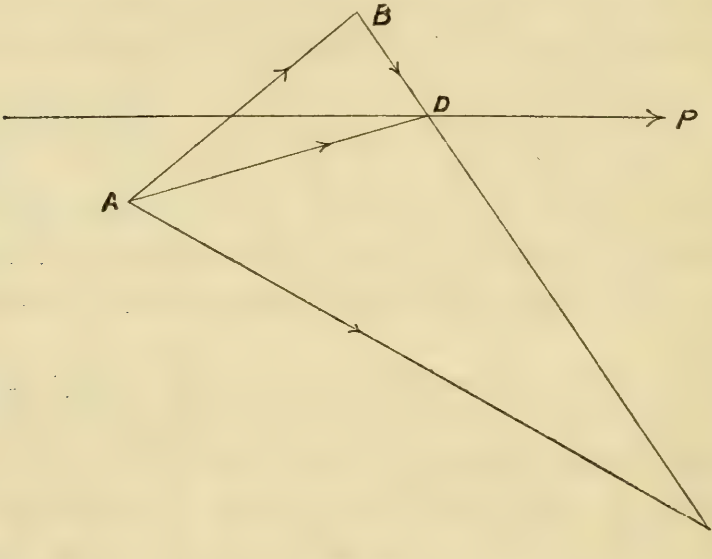


Fig. 2.

The question of the stability of the Eiffel Tower, on account of its great height, involves considerations that do not arise in ordinary buildings. For the base of the tower remaining constant, it is clear that the moment of stability (weight × $\frac{1}{2}$ length of base) varies, roughly speaking, as the height, whereas the overturning moment of the wind varies as the product of the height and the distance of the centre of pressure above the ground, *i.e.* as the square of the height roughly. Hence this wind action acquires special importance, and some way must be found to provide against it. The peculiar and characteristic curve of the tower is the result.

Theory of the Curve.—We can show that any force can be resolved into three components along three arbitrary straight lines in its plane (*Fig.* 2); for if the force P cut one of the straight lines BC in D, then P may be resolved along BD and AD, and AD in its turn may be resolved along the other sides AB and AC.

In the case where P passes through an angular point B, it resolves at once along BA and BC alone, and we get a zero-component along AC.

Now, in the tower let ABCD (*Fig.* 3) represent any one of the storeys, and EF all the rest above it. Let the action of the wind on this latter section be collected at P. Then this force can, as above, be taken by the three girders AB, BD, CD.

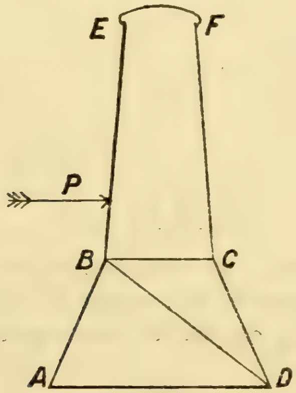


Fig. 3.

And to allow for wind from the contrary direction we shall require another girder joining CA. But if it should happen that P passes through the intersection of AB and DC, it will resolve along AB and CD alone, and there will no longer be any need for the cross pieces BD or AC. Thus a great expense and weight will be saved.

Hence: *the broken line of the tower must be such that the opposite ascending girders of any section meet on the line of action of the wind pressure in that part of the tower which remains above that section.**

---

* When the sections are indefinitely diminished in height and increased in number, the outline becomes a continuous curve. The theory of this curve has been investigated by Mr. A. G. Greenhill in the "Cambridge Philosophical Society's Proceedings," vol. iv., p. 66, from the above property, observing that the "girders of the section" must be replaced by "the girders tangent to any section at its two opposite highest points."

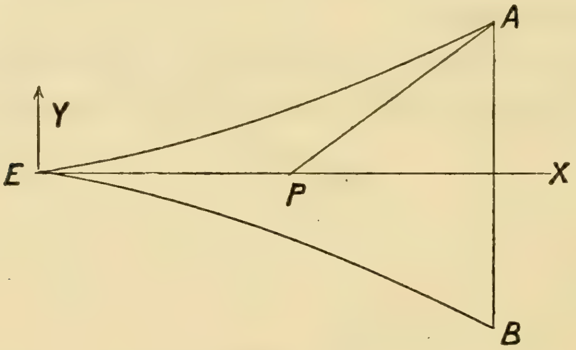


Fig. 4.

Thus, if the tower (lying sideways, *Fig.* 4) be represented by AEB, and we assume that the centre of pressure on the area AEB coincides with its *c.g.*, then if x, y be the co-ordinates of A referred to E as origin, we have—

$$EP=\frac{\int yxdx}{\int ydx}$$

Again, since AP is tangent $\therefore EP=x-\frac{y}{\frac{dy}{dx}}$

$\therefore \frac{\int xydx}{\int ydx}=x-\frac{y}{\frac{dy}{dx}}$. Assume $v=\int ydx$ and $z=\int vdx$ so that $y=\frac{d^2z}{dx^2}$, *Experimental verification.*—[This model, and one like it, shown during the reading of the paper, were executed for me by the kindness of Mr. (now Professor) Selman.] Let AB, BC, CD (*Fig.* 5) be three freely hinged rods, which stand for any section of the tower, and let E, a perpendicular to BC, rigidly fixed to it, stand for the rest of the tower. Let P, Q, R, be strings fastened at various points, which can be pulled so as to represent the action of the wind on the part

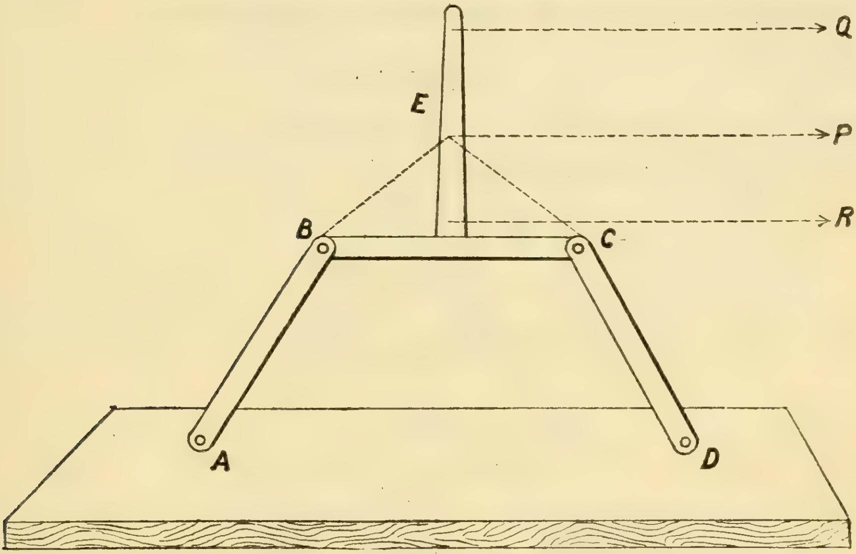


Fig. 5.

we obtain—

$$\frac{\int x\frac{dv}{dx}dx}{v} = x - \frac{y}{\frac{dy}{dx}}, \text{ or integrating the left hand by parts—}$$

$$\frac{xv-\int vdx}{v} = x - \frac{y}{\frac{dy}{dx}}$$

$$\therefore \frac{\int vdx}{v} = \frac{y}{\frac{dy}{dx}} \text{ or } \frac{z}{\frac{dz}{dx}} = \frac{y}{\frac{dy}{dx}} \text{ or}$$

E. If the string P (which is fastened at the intersection of AB, DC) be pulled, the structure remains firm and upright. But if either Q or R be pulled, the frame collapses. In the first case, the rods AB and CD turning leftwards about their pivots, and in the second case, rightwards.

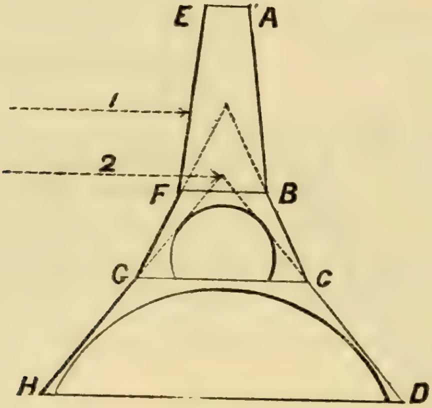


Fig. 6.

It will be observed, that in the well-known outline of the tower these requirements are approximately fulfilled (*Fig.* 6).

$$\frac{\frac{dz}{dx}}{z}=\frac{\frac{dy}{dx}}{y} \therefore \log z=\log y+\text{constant}$$

$$\therefore y=k^2z \text{ where } k \text{ is some constant}$$

$$\therefore \frac{d^2z}{dx^2}=k^2z \therefore z=Ae^{kx}+Be^{-kx}$$

$$\therefore y=\frac{d^2z}{dx^2}=Ce^{kx}+De^{-kx} \ (C=Ak^2,\ D=Bk^2).$$

This is ∴ the equation to the curve.

If the tower goes off to infinity in the negative direction, we get the logarithmic curve $y=Ce^{kx}$, which is probably the one in the Eiffel Tower.

If the tower comes to a point at the origin (and is ∴ a *spire*), we get $y=C\,\mathit{Sinh}\,kx$, the curve of " shines."

Mr. Greenhill also gets the logarithmic curve as the best for a tree, but from independent considerations.

Thus the resultant wind pressure on the highest section EF, (marked 1), acts through the meeting-point of GF and CB, and so the section GFBC is in equilibrium under a push along BC and a pull along GF. Next, including GFBC and FEAB as one section, the pressure on it (marked 2) acts through the meeting-point of HG and DC, so that the section HGCD is in equilibrium. Thus, since each portion of the tower is in equilibrium, so also is the whole tower, and that without the help of cross pieces HC, GD, FC, BG, which are therefore omitted as being unnecessary.

While discussing the stability of the tower, we may inquire whether a system of uniform freely jointed rods, as AB, BC, CD, is stable for small displacements when the link BC is weighted at its middle point (*Fig.* 7). This is essentially the case of the lowest stage of the tower, and, indeed, of every stage.

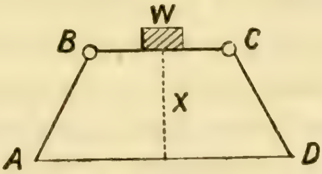


Fig. 7.

The system is unstable. This can be shown in an elementary way as follows: Invert the whole frame so that it swings from AD. Clearly now it is stable for small displacements, for one cannot conceive of its being otherwise. This shows that for a symmetrical position of the rods x is a maximum. But restoring the system to its previous position, this is precisely the condition for instability. It is hardly necessary to point out that this is not a pressing element of danger in the tower, because the overturning forces for small displacements are infinitely small and amply counteracted by the virtual rigidity of the joints.

5. UTILITY OF THE TOWER.

I. *Strategic Observations.*—Light can be flashed from it to a distance of 39 miles, and observations taken at a distance somewhat less.

II. *Meteorology.*—The tower will lend itself to the observation of the strength and changes in direction of the wind, the chemical composition of the air, and the formation of mist, dew, fog, rain, etc., at different altitudes, and the law of the decrease of temperature.

III. *Physical Experiments.*—Falling bodies and resistance of the air, oscillations of pendulum, electric phenomena.

IV. *Astronomical Observations.*—This point is doubtful, as one cannot make sure that the tower will have only a motion of translation and no rotary motion. But it may be useful for spectroscopic work and researches in atmospheric refraction, as it rises above the ordinary level of fog and dust, and sometimes even above the clouds.

But after all, the great utility of the tower is the lesson it affords in working with iron.

Voice, Language, Phonetic Spelling.

BY ARTHUR B. PROWSE, M.D., F.R.C.S.

Abstract of Paper read April 4th, 1889.

SOUND is caused by vibrations, transmitted by the air. Sounds are classified into noises, musical sounds, and vocal sounds. The lowest number of vibrations perceived by the ear is from 15 to 20 per second, and the most acute sound audible is caused by from 20,000 to 70,000 in the same period of time. Voice, or vocal sound, is produced and modified by certain parts of the human body, named the vocal organs; and language is " articulate voice."

Originally the term 'language' was limited to Speech, but its meaning has since been extended—so that we now talk also of " written language " and the " language of gesture." It is a fallacy to maintain, as some have done, that mind is created by language. The custom of accepting as truth *theories* built upon very shaky foundations is far too prevalent in these days. An instance of this " science, falsely so-called," is the very widely accepted theory of the "*evolution of species*," and the still wilder ideas based upon its assumed truth; for while, with one breath, scientists confess that the crucial facts to establish Darwin's ingenious hypothesis are utterly wanting, with the next breath they tell us it must be accepted! Again, a few years ago it was insisted that similarity of language was sure evidence of racial affinity; and because a very large number of our words happen to be allied to the German forms, it was assumed that we came of the same stock as the Germans. It is now, however, acknowledged by all competent authorities that language is not a sure and certain test of race, but only of social contact. There are *no known facts* which prove that we *Britons* belong to the so-called *Aryan* family.

The sound of voice is produced by the vibration of the edges of two elastic bands—the vocal cords—which are situated in the larynx, or upper part of the windpipe; and the sound, conveyed by the air, is modified in various ways by alterations in the shape of the mouth and throat, and in the relations borne by the tongue, palate, teeth, and lips to each other. The simple vowel-sounds of our language are 12, and the consonant sounds 24 in number, making together 36 simple sounds; for each of which there ought to be a letter, which should itself be used for no other sound. With such an alphabet of 36 letters, all the sounds of the language could be truthfully and consistently represented, and there would be no difficulty whatever in spelling.

The lecturer then briefly discussed the chief types of writing in existence, commencing with the simple pictures (iconographs) of natural objects made by prehistoric man, of which diagrams were shown, and as a contrast to them, a copy of a North American Indian letter, in which, though the hieroglyphs were similar in character, they served to convey a series of ideas from the mind of the writer to other minds. Such symbols are called ideographs. Phonographs, or sound-signs, are a further improvement; and these are either syllabic (representing whole syllables) or alphabetic (representing elementary sounds).

In reference to the Aztec, Chinese, and Egyptian writings, and the cuneiform characters of the Assyrians and Persians, it was stated that all include specimens of ideographs and phonographs, but that the proportion of the second class of signs increased successively in these languages in the order given. Finally, in the Hebrew, Phœnician, and Samaritan writings we first meet with an alphabet consisting of phonographs only. From these alphabets the Greeks and Ancient Romans derived theirs, and our own was a slight modification of the later Roman.

Sounds are the essential elements of language, while the true and only function of *letters* is to *represent* these sounds. With our present very defective alphabet it is quite impossible to do this truthfully, and an utterly chaotic condition of spelling is the result, more especially because every letter is used to represent various sounds, and most sounds are variously represented by many letters. Thus, the *letter O* is used to represent five different sounds, while the *sound* of *O* (as in the word "no") is represented in at least 12 different ways.

A complete analysis of the signs employed for different sounds shows that the five simple vowel letters and 83 combinations thereof have together no less than 281 values; and, as regards the consonants, there are 119 different arrangements, with 251 values. With such confusion, it is certain that, as Dr. Morell states, "The ear is no guide in the spelling of English; rather the reverse." Professor Max Müller says, "English spelling is a national misfortune, and in the keen international race between all the countries of Europe, it handicaps the English child to a degree that seems incredible till we look at statistics." Rapp, a distinguished German writer, says: "Did not a whimsical, antiquated spelling stand in the way, the universality of this language would be still more evident; and we other Europeans may esteem ourselves fortunate that the British nation has not yet made this discovery." Similar testimony was quoted from several other philologists and educationalists of note, both British and foreign.

The results of attempting to teach our present spelling may be summarized briefly as follows:—(1) In the elementary schools of the country less than one scholar for each teacher employed, and less than two scholars for each school inspected, reached the very moderate requirements of Standard VI. in reading and spelling. (2) To attain even this mediocrity takes at least six or seven years of school life. (3) A few years ago, in the United States, a Government inquiry revealed the fact that 25 per cent. of the teachers themselves were seriously deficient in spelling. (4) As regards the so-called higher classes, it is a well-established fact that 95 per cent. of the Civil Service candidates that fail are plucked for spelling.

The immense waste of time and the almost complete failure in national education are bad enough, but what is worse is the actual mischief done by subjecting young minds to such illogical training as the current spelling gives them. Everything they have to learn in reading and spelling is irrational; one rule contradicts another, and each statement has to be accepted simply on authority. The exercise of the reasoning faculty is useless. As a simple example, consider the different sounds expressed in the words *on*, *one*, *done*, *tone*; and the various sounds of *ough* in the nine words *hough*, *though*, *through*, *rough*, *borough*, *plough*, *cough*, *hiccough*, *ought*.

How different are the results actually obtained by teaching children a purely phonetic system of spelling! To quote one only: "By the use of phonetic spelling it takes at the utmost one year to teach a child of six or seven years of age, and of average ability, to read and spell fluently, without fatigue or strain to either child or teacher; and 75 to 80 per cent. of the children master the phonetic reading completely in six months only, if they are regular attendants at school. A few months more will then give them the same facility in reading words spelled in the ordinary way." The results attained are well summarized in an article in "Chambers's Encyclopædia" as follows: "There can be no doubt that phonetic spelling would greatly facilitate the acquisition of the power of reading, and consequently the education of children and of illiterate adults; as well as tend to the reduction of dialects to some common standard, and to further the diffusion of our language in foreign countries. To learn to read from perfectly phonetic characters would be merely to learn the alphabet; and to spell would be merely to analyse pronunciation. A child at school could be made a fluent reader in a few weeks. All uncertainty of pronunciation would vanish at the sight of a word, and dictionaries of pronunciation would be quite superfluous."

The four principal objections raised against spelling reform were then considered:

1. The *Linguistic* objection, which is that phonetic spelling will alter the sounds of our language. This statement is due to gross ignorance of what phonetic spelling is; and partly also to the idea that language consists of written signs rather than of sounds. A change of spelling is not a change of language. Phonetic spelling will tend to preserve the sounds, of which language is composed, in their purity.

2. The *Etymological* objection: People say phonetic spelling destroys etymology. That this statement is untrue is abundantly proved by the unanimous testimony of all living

philologists and etymologists of note. Professor Skeat, of Cambridge, author of the most valuable etymological dictionary we have, says, "In the true interests of etymology I should be glad to see all spelling purely phonetic." Rev. A. H. Sayce, Deputy Professor of Philology at Oxford, says, "The objection that a reformed spelling would destroy the continuity of a language, or conceal the etymology of its words, is raised only by ignorance and superficiality. English spelling is good for little else but to disguise our language, to hinder education, and to suggest false etymologies."

Several other high authorities were then quoted in favour of phonetic spelling being an aid to etymology, and finally Max Müller's opinion: "Language is not made for scholars and etymologists, and even if the whole race of etymologists were really to be swept away by the introduction of spelling reform, I hope they would be the first to rejoice in sacrificing themselves in so good a cause."

3. The *Historical* objection. The simple fact, attested by all scientific students of language, that there are hardly any words which are now spelled "historically," as it is called, is sufficient answer to the assertion that phonetic spelling would destroy the history of our words. It is generally supposed that the current spelling has been in existence from some very remote period; but the simple fact is that it may, in the main, be traced back to Johnson's dictionary (1755), and to what Max Müller calls "the capricious sway exercised by the large printing offices and publishers."

4. The *Homonymical* objection, which is that by spelling phonetically words which are now spelled differently, though they have the same sound, great confusion would be caused. The superficiality of this objection is manifest when it is remembered that we do not now get confused

when using the hundreds of words in our language, which, with different meanings, have nevertheless the same sound and spelling. To be consistent, these objectors ought to use different spellings to indicate the eight different meanings of the word *box*, and the six different meanings of the word *bay*, etc.

One of the advantages of phonetic spelling is that it would serve to distinguish between words, which, with different sounds and meanings, are now spelled alike, *e.g.*, *bow*, *tear*, *minute*, *wound*, *read*, etc. Several of the objections urged against spelling by sound are very trivial; and time does not allow of their consideration.

In spite of our corrupt and chaotic spelling, which is the great difficulty foreigners have in learning it, our language is making its way into all parts of the world. This is partly owing to our world-wide distribution and commercial influence; partly to the fact that, apart from its spelling, our language is one of the most easily acquired by other races; and it is, as many foreign philologers have remarked, the best vehicle of communication the world has ever seen, freed as it is from grammatical forms, declensions, genders, and the like. No other tongue can compete with it, not even that extraordinary production of continental jealousy of Britain and her world-wide influence, Volapük, which is destined to die a natural death ere long.

When the day comes, as come it will, when truth and reason shall have prevailed, and our "corrupt and effete" orthography, as Max Müller terms it, shall have been discarded in favour of spelling by sound, then the last barrier will have been levelled which at present hinders our "pure language" attaining the goal it is approaching, and which delays the fulfilment of its manifest destiny as the language of the world.

Reports of Meetings.

GENERAL.

THE past session has been characterised by two features of more than usual interest. At the November meeting Dr. Dallinger, F.R.S., gave his lecture on "Putrefactive Organisms," and on April 26th the Society held a very successful Scientific Soiree. In addition, the papers and communications which have been given at the remaining seven meetings of the Society have been fully up to the average merit and number; the members meeting, as usual, at the University College, excepting on the occasion of Dr. Dallinger's address, when they met in the Lecture Room of the Bristol Museum.

On Thursday, October 4th, 1889, Professor Leipner exhibited the fruit and foliage of the Bladder-nut (*Staphylea pinnata*) found by him in a shrubbery in Buckinghamshire, and Dr. Munro Smith gave a demonstration of Apparatus used in physiological research.

On November 6th the Rev. Dr. Dallinger gave his lecture upon "Putrefactive Organisms," illustrated by the oxy-hydrogen light. An abstract report of his address appears at page 86.

At the meeting held December 6th, Mr. C. K. Rudge, on behalf of Mr. Charbonnier, exhibited and commented upon specimens of Pallas's Sand Grouse (*Syrrhaptes paradoxus*) and Eider Duck, also a young Puffin found at Cheddar. Papers were read by Mr. G. I. Trusted on "*Talpa* (Mole), and some Remarks on its Habits" (see Proceedings, page 56), and by Mr. C. Jecks on "Suggestions as to the Causes of Difference in Colour between Flowers and Foliage of Tropical and Temperate Regions," which will be found at page 121.

At the January meeting, held on 6th inst., Mr. Charbonnier showed a specimen of Grey-backed Shrike, or Butcher-bird, shot at Abbot's Leigh. Dr. Munro Smith exhibited and remarked upon the Water-cells of the Camel's Stomach (Proceedings, page 118), and Prof. Leipner gave a paper on "Plant Life."

On February 7th, Dr. A. J. Harrison read a communication upon the vexed question of ophidian fascination, headed "Do Snakes Fascinate their Victims?" (see page 67), which was followed by an interesting communication from Dr. W. Duncan on a similar subject, entitled, "Notes on *Trigonocephalus lanceolatus*, the Fer de Lance Snake of Santa Lucia and Martinique."

On March 6th Prof. Lloyd Morgan gave a paper on "Perception of Animals." An abstract of this will be found at page 116.

At the meeting held April 4th, Dr. Arthur B. Prowse gave an exhaustive and interesting paper upon "Voice, Language, and Phonetic Spelling," an abstract of which is printed at page 153.

At the last general, which was also the 27th annual, meeting, the Hon. Sec. (Prof. Leipner) read the Report of the Council, the balance-sheet was presented, and the officers for the ensuing season were appointed. The Hon. Secretary urged upon the members the importance of individual effort in extending the influence and limits of the Society, point-ing out that the value of its work was well attested to by the ever-increasing demand from kindred societies, both at home and abroad, for the Bristol Society's published proceedings, the exchange list at present including fifty-nine British and thirty-four Colonial and Foreign Societies.

Mr. Charbonnier then exhibited a specimen of the Bell Bird, so named from its note, a native of British Guiana, remarkable for the curious appendage to its beak. Mr. C. K. Rudge showed, under the microscope, a rare fresh-water Polyzoon, *Cristatella mucedo*, and Prof. Leipner brought for the inspection of the members a complete series of *Comatula rosacea*, the rosy Feather-star dredged up by him off Ilfracombe, and a slab from the Lias of Lyme Regis containing some beautiful specimens of an ancient allied form, *Pentacrinus Briarius*.

HENRY A. FRANCIS,
Hon. Reporting Secretary.

REPORT OF THE BOTANICAL SECTION.

THE exploration of the Bristol Coal-field has gone on, although it is chiefly due to the work of outsiders that "Supplemental Notes" are being published, containing particulars of four species new to the local "Flora," as well as information of scarcely less importance relating to other uncommon plants.

J. W. WHITE, F.L.S.

July 9, 1889.

CHEMICAL AND PHYSICAL SECTION.

THE Section has held four meetings since the last Report, and a number of papers have been read, one of which is printed in the Proceedings.

The following are the names of gentlemen who have read papers during the Session: Mr. A. Campbell, Mr. G. F. Schacht, Mr. G. E. Crawford, and Mr. D. Rintoul.

A. RICHARDSON, *Hon. Sec.*

GEOLOGICAL SECTION.

THERE has been one meeting of the Section, at which Mr. A. Wharton Metcalf was elected Secretary.

The Rev. Morley B. Saunders read a paper on "Mountain Building," which is printed in our Proceedings.

The President stated that he was engaged on a piece of geological work in the neighbourhood of Tytherington and Grovesend, and briefly alluded to some of the features seen in the Yate and Thornbury railway cutting. A paper on the subject will be found in the pages of the Proceedings; and it is proposed to make an excursion to the district.

The President also alluded to the Brislington section on the Great Western Railway, and promised to read a paper on the section during the next Session.

An excursion of the Section was made, at Whitsuntide (1888), to Frome. On the Saturday the chalk outlier of Cley Hill was visited. On Monday the members examined the Mountain Limestone, and the Rhœtic fissure-infillings of Nunney and Holwell. On Tuesday the railway section near Old Down Inn and the rocks in the neighbourhood of Binegar were visited. The President, the Rev. H. H. Winwood, Mr. Joel Lean, and others drew attention to the salient features of the geology of the district.

ENGINEERING SECTION.

On the 30th of June, 1888, an excursion of members and friends, to the number of thirty-five, was made, under the guidance of Mr. Charles Richardson, President, to the Severn Tunnel Pumping Stations. After visiting the Stations, the party dined together at the Black Rock Hotel, Portskewet.

On the 20th December, 1888, about twenty-five members dined together at the Queen's Hotel, Clifton.

A farewell dinner was given on the 22nd March, 1889, at the Queen's Hotel, to Mr. Sutcliffe, member of Committee, on the occasion of his leaving Bristol for an appointment at Goole under the Aire and Calder Navigation.

During the Session eight Meetings were held. The following Papers were read:—

"The Severn Tunnel: its Origin and Construction," Mr. Charles Richardson, C.E. (President); "Sewerage Systems," Mr. A. P. I. Cotterell; "Mechanical Testing Machines, and the Behaviour of Metals under Stress," Mr. D. C. Selman; "Bells and Bell-Founding," Mr. J. D. Noble; "The Warehousing of Grain," Mr. J. M. McCurrich; "The Eiffel Tower: its Conditions of Stability," Mr. D. C. Selman.

In connection with Mr. McCurrich's Paper about thirty members visited on the 5th April, 1889, the New Granary, Princess Wharf, Bristol, and by the kind permission of Mr. Girdlestone, Docks Engineer, inspected the building and machinery.

NICHOLAS WATTS, *Hon. Sec.*

Note.—All the papers were read prior to April 16th, except Mr. Selman's on the Eiffel Tower.—N. W

The following Publications of the Bristol Naturalists' Society may be obtained either from Messrs. Fawn & Son, Royal Promenade, Bristol, or from the Honorary Secretary.

Proceedings, New Series.				
Vol. I.,	Part	1,	1873–74.	4*s.*
,, ,,	,,	2,	1874–75.	5*s.*
,, ,,	,,	3,	1875–76.	4*s.* 6*d.*
,, II.,	,,	1,	1876–77.	3*s.* 6*d.*
,, ,,	,,	2,	1877–78.	3*s.* 6*d.*
,, ,,	,,	3,	1878–79.	3*s.* 6*d.*
,, III.,	,,	1,	1879–80.	3*s.* 6*d.*
,, ,,	,,	2,	1880–81.	3*s.* 6*d.*
,, ,,	,,	3,	1881–82.	3*s.* 6*d.*
,, IV.,	,,	1,	1882–83.	3*s.* 6*d.*
,, ,,	,,	2,	1883–84.	3*s.* 6*d.*
,, ,,	,,	3,	1884–85.	3*s.* 6*d.*
,, V.,	,,	1,	1885–86.	4*s.*
,, ,,	,,	2,	1886–87.	5*s.* 6*d.*
,, ,,	,,	3,	1887–88.	5*s.*
,, VI.,	,,	1,	1888–89.	4*s.*

Flora of the Bristol Coal-Field. By James Walter White. One vol. bound. 6*s.*

The Fungi of the Bristol District. By Cedric Bucknall, Mus. Bac.

Part IV.	Species	690 to 836.	4 plates, 3 coloured, 1 black.	1*s.* 6*d.*
,, V.	,,	837 to 934.	2 ,, 1 ,, . . .	1*s.*
,, VI.	,,	935 to 1023.	1 plate, black	1*s.*
,, VII.	,,	1024 to 1084.	. . . .	6*d.*
,, VIII.	,,	1085 to 1144.	3 plates, coloured	1*s.* 6*d.*
,, IX.	,,	1145 to 1240.	4 plates	1*s.*
,, X.	,,	1241 to 1321.	4 plates	1*s.*

On the Newly-Discovered Phenomenon of Apospory in Ferns. By Charles T. Druery, F.L.S. Illustrated. 1*s.*

Contributions to the Geology of the Avon Basin. By Prof. Lloyd Morgan, F.G.S. I. "Sub-Aerial Denudation and the Avon Gorge." Coloured Map. II. "The Millstone Grit at Long Ashton, Somerset." With Map. 1*s.*

III. "The Portbury and Clapton District." IV. "On the Geology of Portishead." 2 coloured maps and 2 plates. 1*s.* 6*d.*

Sleep and Dreams. By George Munro Smith, L.R.C.P. Lond., M.R.C.S. 2 plates. 1*s.*

The Bone-Cave or Fissure of Durdham Down. By E. Wilson, F.G.S., Curator of the Bristol Museum. 2 plates. 1*s.*

Notes on a Common Fin Whale, lately stranded in the Bristol Channel. By E. Wilson, F.G.S., Curator of the Bristol Museum. Photograph. 1*s.*

The Severn Tunnel. By Charles Richardson, C.E., and Notes on the Geology of the Section by Prof. Lloyd Morgan, F.G.S. With geologically coloured Section of Tunnel, map and plate. 2*s.*

The Mendips: A Geological Reverie. By Prof. C. Lloyd Morgan, F.G.S. 1*s.*

The Arch. By Charles Richardson, C.E., with illustrations. 1*s.*

ADOLPH LEIPNER, Hon. Sec.

47, Hampton Park, Clifton.

NEW SERIES, Vol. VI., Part II. (1889-90). Price 3s. 6d.

PROCEEDINGS

OF THE

BRISTOL NATURALISTS' SOCIETY.

EDITED BY THE HONORARY SECRETARY.

BRISTOL NATURALISTS' SOCIETY

Rerum cognoscere causas."—VIRGIL.

BRISTOL:

PRINTED FOR THE SOCIETY.

MDCCCXC.

NEW SERIES, Vol. VI., Part II. (1889–90). Price 3s. 6d.

PROCEEDINGS

OF THE

BRISTOL NATURALISTS' SOCIETY.

EDITED BY THE HONORARY SECRETARY.

BRISTOL NATURALISTS SOCIETY

"*Rerum cognoscere causas.*"—VIRGIL.

BRISTOL:

PRINTED FOR THE SOCIETY.

MDCCCXC.

TABLE OF CONTENTS.

NEW SERIES, VOL. VI., PART II.

PAGE

Three Geological Papers. By Prof. C. Lloyd Morgan, F.G.S.:

I. The Brislington Cutting 165

II. Mendip Notes 169

III. The Geology of the Wick Rocks Valley . . . 183

The Fungi of the Bristol District. Part XII. By Cedric Bucknall, Mus. Bac. 189

Rainfall at Clifton in 1889. By George F. Burder, M.D., F.R. Met. Soc. 195

Observations of Temperature at Clifton, 1889. By D. Rintoul, M.A. Cantab. 198

Observations on a Pair of Blackbirds. By H. Percy Leonard . 202

Some British Wild Bees. By Henry A. Francis, F.R.M.S. . . 213

On the Reconstruction of Viaducts on the Cornwall Railway. By Albert P. I. Cotterell, Assoc. M. Inst. C.E. 217

Investigation of the Board of Trade Formulæ for Strength of Firebox Girder Stays. By J. W. I. Harvey 232

Reports of Meetings, General and Sectional 243

I.

The Brislington Cutting.

By Prof. C. LLOYD MORGAN, F.G.S., Assoc. R.S.M.

THE Great Western Railway Company have recently converted the No. 1 tunnel between Bristol and Bath into a wide wall-sided cutting. Mr. Charles Richardson kindly took me to see the cutting in an early stage, and with the permission of Mr. W. K. Lawrence, I have since frequently visited the spot. Mr. Lawrence was good enough to promise me a copy of the section he was having drawn to scale. I learn from him, through Mr. Richardson, however, that this section has been mislaid. I have therefore drawn a rough sketch, which indicates the geological features exposed in the cutting (Fig. 1). The second sketch (Fig. 2) shows on a larger scale, and with greater accuracy of detail, a portion of the cutting on the N. side about twenty yards W. of the existing signal bridge.

The cutting runs from a little N. of West to a little S. of East. At the Bristol or Western end the whole face of rock exposed is in the Trias; but soon the ancient Palæozoic floor rises in an undulating line, so that, as seen in Fig. 1, the rock exposed at the Eastern end of the cutting is entirely Pennant. These strong coal-measure sandstones have a general

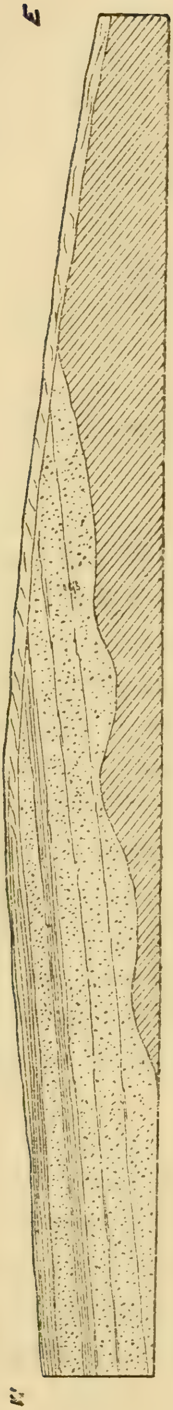


Fig. 1

dull-red colour, though in the deeper fracture the rock, especially where it is more massive, is bluish grey. The dip is from 20° to 30° S. 10 E. It is much jointed and troubled with little faults of small throw. The main joints run N. 20° W. In the Pennant were a number of large rounded or oval shrinkage nodules similar to that which stands on a pedestal at the Bath end of the cutting. Similar shrinkage nodules were found in the Millstone Grit of the Patchway tunnel.

The Triassic beds dip N. 70 W. at a gentle angle of about 5°. The basement beds immediately overlying the Pennant are red and tolerably hard, and had to be blasted in the engineering operations of the cutting. From their hardness and the similarity of colour, they were not readily distinguishable at a little distance from the Pennant itself. Examined with the lens, the rock is seen to contain rounded or subangular grains of sand cemented with calcareous matter containing a good deal of red oxide of iron. Treated with acid, the stone effervesces freely. A hundred grains thus treated yielded 57½ grains of red sandy residue. The material dissolved contained no magnesium, and was almost entirely carbonate of calcium. There can be little doubt that this carbonate of lime was precipitated with the sand from the saline waters of the Keuper Lake as they gradually

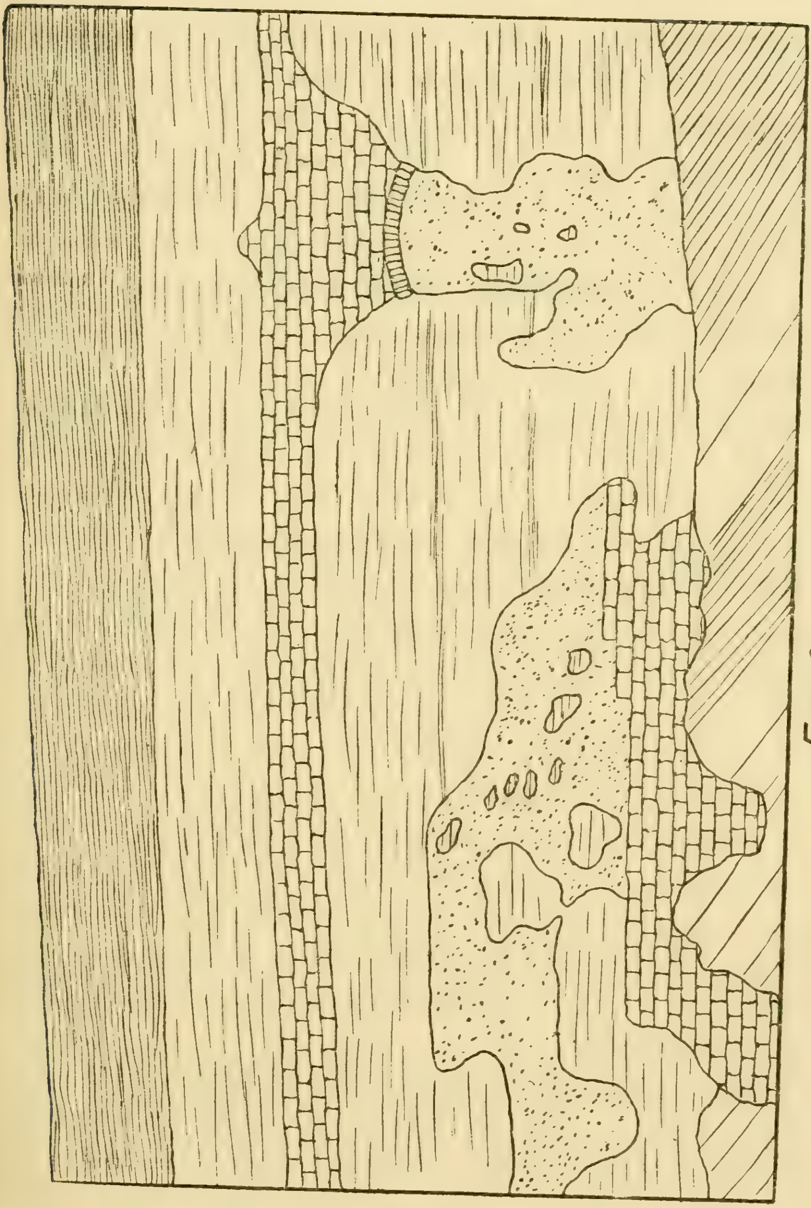


FIG. 2.

extended over the Bristol district. There is nothing here of the nature of the so-called Dolomitic Conglomerate which is found fringing the islands of the Keuper Sea.

A thin bed of marl (now bricked in) separates a lower and thicker mass of this calcareous sandstone from an upper and thinner stratum of similar materials (see Figs. 1 and 2). The upper part of the section at the W. or Bristol end consists of ordinary red Triassic marl. This is now a grass-grown slope. The slope is carried along the whole length of the section (as indicated in Fig. 1 by the line conformable to the surface). This gives the appearance of the marl overlying the red calcareous sandstone unconformably, an appearance which deceived me at first. Subsequent examination, when the sloping bank was being trimmed back, led me to see that the slope to the Eastern end of the section is not in Trias marl, but in decomposed calcareous sandstone, in which occasional nodules which had escaped disintegration could be found.

Fig. 2 was sketched while the walling up of parts of the face of the cutting was in progress. At the surface is the Triassic marl, now grass-grown. Below it is the band of red calcareous sandstone, followed by a band of marl bricked in. Between this and the Pennant at the base of the section are the red calcareous basement beds. But the parts dotted and partly bricked in, in the sketch, are composed of very soft friable yellow and brown ferruginous sand. In it there are nodules of calcareous sandstone of various sizes and shapes. There were many such irregular patches of ferruginous sand, so soft that it could be scraped away with the hand. These are now bricked in.

There can be little doubt that these were produced by the solution of the cementing calcareous matter by water, containing probably carbonic acid gas dissolved in it. The contained nodules are masses of the original material which have escaped disintegration in this way.

II.

Mendip Notes.

By Prof. C. LLOYD MORGAN, F.G.S., Assoc. R.S.M.

NOTWITHSTANDING the admirable geological work, official and unofficial, that has been done in the Mendip Hills, there still remain many points which, to me at least, are far from satisfactorily explained. No one has yet given an adequate explanation of the system of faults and thrusts by which the Vobster and Luckington Limestones have reached their present position. The bands of grit and shales associated with the Vobster limestone point to the fact that the beds may probably be referred to the Upper Transition Beds (Upper Limestone Shales) of the Avon section. Little is known, however, concerning the Mendip beds of this horizon. We possess, in fact, very little accurate knowledge concerning the Millstone Grit and underlying beds in the Mendips, and that little seems to point to conditions of deposit somewhat different from those which obtained further north.

In a memoir I have promised to prepare for the Bristol Naturalists' Society, *On the Geology of the Avon Basin and the Mendip Hills*, I hope to publish the results of my own observations in this interesting district. There are one or two points, however, to which I propose to direct attention, without further delay, in the following notes:—

EMBORROW.

South of Emborrow, near Lechmere Water, one can, on the Geological Survey map, cover with the end of a cedar pencil Old Red Sandstone, Lower Transition Beds (Lower Limestone Shales), Mountain Limestone, Millstone Grit, and Coal-measures. A fault is indicated between the Old Red and Lower Transition Beds on the one hand, and the Millstone Grit and Coal-measures on the other. But even when the fault is taken into consideration, it is difficult to see how samples of all these Palæozoic beds come to be huddled together around Lechmere Water.

In the Survey Memoir we read:—

"South of Emborrow a small tract of rather complicated ground occurs, and it will be best to consider here all the rocks embraced in it. South-east of the church black coaly shales have been dug up, apparently an old shaft having been sunk. At Lechmere Water we find an adit level driven into the hill towards the church. Commenced in the Lower Limestone Shales, it is continued into the Old Red Sandstone, showing the passage between the two. Old Red Sandstone is seen by the cottage on the south side of the water. These beds must be faulted against the Coal-measures. To the south-east, on the northern side of the ravine, Millstone Grit occurs, and it stretches probably to Emborrow Church, where it is concealed by the Lias chert. . . . The trace of Coal-measures which is exposed no doubt comes out conformably above the Millstone Grit, which again overlies the Carboniferous Limestone. These beds are faulted against the Old Red Sandstone and Lower Limestone Shales" (p. 16).

Some years ago my attention was drawn to this pretty and interesting spot by Mr. Henry E. Hippisley. I was puzzled and dissatisfied. Last summer I went over all the ground very carefully with Mr. Hippisley, and came to conclusions which differ from those expressed in the Survey publication. Mr. Hippisley also lent me some MS. notes made by his father in 1854 and 1857, when certain trials for coal and iron were being made in the neighbourhood. These notes confirmed the results of our re-examination of the locality.

There are neither Lower Transition Beds nor Old Red Sandstone near Lechmere Lake. The beds that have been accounted such are probably shales and sandstones of the Millstone Grit. The so-called Coal-measures are probably carbonaceous seams in the Millstone Grit, or that series which, overlying the Mountain Limestone in the Mendip area, answers to the Millstone Grit. If this be so, then, in place of the puzzling patchwork of the Survey Map, we have beds of Millstone Grit faulted against the Mountain Limestone.

The following are some of the facts and observations on which my conclusions are based :—

(1) The Limestone to the East of Lechmere Water, where, according to the Survey Map, it adjoins the Lower Transition Beds, contains no encrinital stems and no Spirifers, as it should do were it Lower Limestone; but does contain Lithostrotion, which points to Upper Limestone.

(2) The adit or heading described in the Survey Memoir, as commenced in the Lower Limestone Shales, and continued into the Old Red Sandstone, is twenty-seven yards long, with, near its mouth, a drift of ten yards driven to the E. It passes through grey micaceous shales with carbonaceous specks, and reaches hard close sandstone resembling Millstone Grit. About three-fourths of the way in there is red sand-

stone resembling Old Red Sandstone. In the drift there is a thin coal-seam, together with shale, resembling the "pan" of coal-miners, in which there occur indications of Stigmaria rootlets (dip 27° SSE). The shales do not resemble those of the Lower Transition Beds, which may be examined in the cutting near Maesbury Station two or three miles further South.

A hundred yards or so to the West of this adit is another heading which was driven about thirty-seven yards. It was, as described in Mr. Hippisley's notes, "carried as far as water flint bed seen in the pond bank" (*i.e.*, a white, close, Millstone Grit), "a vein of coal and two inches good fire-clay proved." "Three beds of laminated clay-stone. Good iron shown in crucible."

A hundred yards or so still farther West is another heading, "carried to stout rocks thirty-four yards from hedge, Farewell rock to wit." Here, as in the first heading, there is, near the mouth of the heading, hard close Millstone Grit, together with fragments resembling very closely Old Red Sandstone.

Yet farther West, a little beyond the end of the pond, there is a cowshed built of Millstone Grit, of which Mr. Hippisley notes that it has "Farewell rock for floor."

These headings and exposures are to the West of the adit mentioned in the Survey Memoir. To the South-East of it, on the other side of the road, a heading was driven ninety-five yards in "very faulty ground." The beds were perpendicular and irregular." In it were found the "end of a (coal) vein," and "indications of a vein and fire clay." And again, a little farther East, and higher up the hill, there was made, in 1857, "a gutter for draining six feet deep along hedge. At bottom, coal-measures, clay, and greys."

(3) In the Survey Memoir we read: "Old Red Sandstone

is seen by the cottage on the South side of the water." This Sandstone is lithologically very like Old Red. The dip is 35° SSE., that is to say, similar in direction to but rather steeper than that in the adit. About two hundred and fifty yards to the South-West there are several old pits in the spoil heaps of which fragments of shale, resembling pan, with little bits of coal, may be found in abundance. Another two hundred and fifty yards or so further South-west are beds resembling Millstone Grit.

These are some of the observations, past and present, upon which I base my conclusion, that Old Red Sandstone and Lower Transition Beds are coloured in on the Survey Map as the result of the erroneous interpretation. Of course, if Lower Transition fossils can be found, the existence of these beds could not be questioned. I have searched in vain for such fossils, and found instead coal-flecks and indications of rootlets.

On remapping the ground on the six-inch scale, I find that the probable run of the fault is from "707" to the north of "Quar Tyning" on that map, through the middle of the large *R* of Emborrow; or on the one-inch map from the S.W. point of the fault, as marked on the Geological Survey's publication, to between the *h* and the *m* of the word "Lechmere" in "Lechmere Water." To the N.W. of this line Millstone Grit, with beds of pan, thin coal seams, and some clay-iron, has been brought in.

EBBOR.

In the picturesque little valley which runs in a north-westerly direction from the mouth of the Ebbor Gorge we have again a puzzling association of Old Red Sandstone, Lower Transition Beds, and Millstone Grit. Here again the insertion of Old Red and Lower Transition Beds is due to erroneous interpretation.

"A little east of the lane" (between Easton and Priddy), we read in the Survey Memoir (p. 30), "near the bend, there is a shallow hole, apparently a trial shaft, from which black Carbonaceous Shales have been obtained, and which, no doubt, are beds belonging to the Millstone Grit."

Farther down the valley is another much more recent pit. Of it, Messrs. Bristow and H. B. Woodward write (*Geological Magazine*, vol. viii., p. 501, 1871): "We were astonished, when paying a visit to the spot in October, to find a shaft was being sunk in search of coal in the Lower Limestone Shales, which had evidently been passed through, inasmuch as the rock then brought to the surface was Old Red Sandstone. The fragments of Carbonaceous shale in the old trial-shaft had probably misled the prosecutors of the second undertaking to suppose that the coal-measures were present, and that lower down in a southerly direction, they would be likely to succeed in finding coal.

"A more unpromising place for finding coal could scarcely have been selected anywhere in the neighbourhood, for the spot where the shaft was being sunk is closely surrounded on all sides by rocks of greater age than the Coal-measures; in fact, the little valley in which the works were being carried on may, in general terms, be described as two narrow strips of Lower Limestone Shale and Old Red Sandstone a few chains wide, and surrounded by higher ground composed of Mountain Limestone. The sinking of this shaft under such manifestly hopeless conditions shows a want of knowledge of the elements of geology and coal-mining that could scarcely be supposed to exist in the present day on the part of persons likely to embark in a search for coal within five miles of a cathedral city."

There is a touch of irony in the fact that those who thus spoke of the blunders of others should in the same paragraph have committed a more serious blunder themselves.

There is no satisfactory evidence of the parallel strips of Lower Transition Beds and Old Red Sandstone. In the illustrative section given in the paper from which I have quoted, the Mountain Limestone at the mouth of Ebbor Gorge is figured as Lower Limestone just above the Lower Limestone Shales. If so, encrinital ossicles should be abundant, and Spirifers should not be absent. On the other hand, the rocks show Lithostrotion, and have the appearance of Upper Limestone. I cannot accept this section as truly or satisfactorily interpreting the facts.

I do not propose, however, to do more in this note than indicate the evidence which leads me to conclude that the insertion of Old Red and Lower Limestone Shales is incorrect, and that Millstone Grit, with associated carbonaceous shales, extend down the valley.

Near the top of the valley, where the lane from Easton to Priddy crosses it, near the gate, strong beds of Millstone Grit are seen *in situ* dipping about 75° S.W. A hundred yards or so south of this is the old pit mentioned in the Survey Memoir, in the spoil-heap of which are not only Carbonaceous Shales, but fragments of true coal. South and a little East of this there is another old pit, a little below the footpath that crosses the valley, with similar shales. An ash tree is now growing in it. Fifty yards or so farther down the valley, across the hedge, is yet another old working with similar black shales in the tip. So far as I can judge from the one-inch Survey Map we are here already in the supposed Lower Limestone Shales. But the three old pits form a chain: the shales which lie around them in the old spoil-heaps are in the main similar, and there is no evidence of a great fault, with a throw of some thousands of feet. Less than two hundred yards farther down the valley are the workings of 1871, said to be in Lower Limestone Shales, and penetrating to Old

Red Sandstone.* There is certainly no evidence of a great fault in this two hundred yards. I can scarcely distinguish a specimen I obtained from the older tip from one I obtained from the more recent heap. There is, in fact, nothing to lead one to suppose that of this continuous chain of pits some are in the Millstone Grit, some in Lower Limestone Shales.

Furthermore, all down the North-eastern slope of the valley, as far as, and to a considerable distance beyond, the 1871 workings the sides of the hill are strewn here and there with blocks of Millstone Grit.

Is there any discordance of strike which would lead one to suppose that the shales in the upper part of the valley are of a different series from those in the lower part of the valley? No. The dips are high, nearly vertical in places; and the strike is nearly uniform N.W. and S.E.

Is the lithological character of the beds markedly different? No. The shales and sandstones of the coal-measure type in the various old workings seem to have been on the whole similar. There are nearly vertical shales in the Priddy lane, which closely resemble nearly vertical shales two hundred yards or more beyond the 1871 tip.

I cannot but suppose that the similarity of some of the sandstone to Old Red led to the insertion in the Survey publications of a strip of this rock.

But here, as at Emborrow, I say, if Lower Transition fossils can be produced from the shales, the question of the existence of these beds at Ebbor is at once settled. I have searched for them in vain.

I may here note that there is evidence of one more trial pit. It is two or three hundred yards to the West of the entrance of Ebbor Gorge, near a ruined building. The shales in the tip are dull red ; and the trial must have been made close to the Mountain Limestone. There may be a fault along the slope of the hill here. The relations of the two masses of Limestone, one on either side of the valley, are puzzling. I do not think either of them belong to the lower or encrinital series. At present all I am prepared to contend for is the abolition of the strips of Old Red Sandstone and Lower Limestone Shales and the mapping of Millstone Grit, or that which seems to take its place in the Mendip area, in their stead.

---

* The Rev. H. H. Winwood informs me that on lithological grounds he was led to regard the sandstone which had been brought to surface as Pennant or a rock of the Coal-measure Sandstone type.

It may here be noted that near the top of the Ebbor Valley, and yet farther West where the old ruined farm buildings stand, the strong Millstone Grit band is conformable to and at once succeeds on the Mountain Limestone. I have not at present found evidence of bands of grit in the Limestone below this. It would seem, therefore, that the Millstone Grit succeeds directly on the Limestone without the intervention of the Upper Transition Beds of the Clifton section. As before stated, however, the relations of the beds which form the upper part of and succeed on the Mountain Limestone in the Mendips need further elucidation. I think it *may* be found that in the Southern Mendips the Upper Limestone is (1) succeeded by shales grits and thin coal beds as at Emborrow and Ebbor; and (2) these again succeeded by Limestone. In this way the outlying Limestone hills south of the Mendip area would be less puzzling; and if this could be proved south of the Mendips it might throw light on the Luckington and Vobster Limestones. The mantle of secondary rocks, however, over all the lower ground must render it very difficult to test the correctness of this view, which is here thrown out merely as a suggestion.

DURSDON, NEAR WOOKEY.

Geologists are well acquainted with the fine face of Dolomitic Conglomerate, here forming the basement beds of the Trias, beneath which the Wookey stream issues. This Dolomitic Conglomerate occupies an old valley stretching up into the Mendips as far as Dursdon. When the Mendips were sinking slowly and gradually beneath the waters of the Triassic sea or lake, the fragments which strewed the sides of the hills were collected into this fringing deposit which here and there, as in the old Wookey Valley, forms tongues or inlets into the Palæozoic area now exposed by a later denudation.

Near the upper end of this tongue there are well-marked, and now well-exposed, deposits of iron ore and manganiferous iron ore which are being worked by the *Somersetshire Manganese and Iron Company.* The deposits are very irregular, and occur mainly in the Dolomitic Conglomerate. But they are also described as passing down into the underlying Mountain Limestone, whether as lodes or as infillings of cracks from the surface is uncertain. I incline to the latter view. There are also sparry veins containing little strings of Galena. The locality is well worth a visit, and I have to thank Col. Harcourt and the Secretary of the Company, Mr. J. Bicknell, for kindly giving me the opportunity of examining it.

CHEDDAR.

"Old Red Sandstone of a very compact nature occurs about one mile to the South-east of Cheddar, accounted for probably by a fault. The surface of the ground is sloping and much overgrown with furze, but the stone has been quarried in two or three places where tolerably good sections are exposed." ("Survey Memoir of East Somerset," etc., p. 16. From Mr. Blake's Notes.)

Concerning this locality, I will only transcribe the note I made on the spot. "In an orchard up on side of hill, much overgrown with bracken and some furze, many fragments of red sandstone or quartzite. Many of them very hard like Millstone Grit; some of them with rusty spots like the Millstone Grit near the dilapidated buildings West of the lane from Easton to Priddy, near the Ebbor Valley, some softer and more like Old Red Sandstone. In a field below, cattle pond, sides of which have very hard Red Sandstone like Millstone Grit. On the whole I am inclined to regard this as Millstone Grit *not* Old Red Sandstone. The relation to other rocks not clear."

BURRINGTON COMBE.

I have been desirous of obtaining satisfactory data for estimating the thickness of the various subdivisions of the Lower Carboniferous series of deposits in the Mendip area, and have collected a considerable body of observations.

It has been mentioned above that there seems some doubt whether the Upper Transition Beds (Upper Limestone Shales) of the Avon Section are represented as such in the Mendip area.

The Lower Transition Beds are, however, well represented, and contain the equivalent of the Bryozoa Bed of the Clifton Avon Section. They may be measured with fair accuracy at Burrington Combe, where it is also possible to estimate the thickness of the Lower or Encrinital Limestone, and the equivalent of the Gully Oolite of the Clifton Section. It may be possible also to estimate the thickness of the Lower Transition Beds in the railway cutting between Binegar and Maesbury, near the latter station (misspelt Masbury by the G.W.R.). The lower limit is there, however, obscured, and I have not, as yet, calculated out the thickness.

Figs. 3 and 4 give a map and section at Burrington Combe. From the observations there recorded the estimated thicknesses are as follows:—

	Feet.
Upper or Lithostrotion Limestone (including "Mitcheldeania" Beds of Clifton Section) .	700
Gully Oolite	250
Lower or Encrinital Limestone . . .	1,300
Lower Transition Beds	350
	2,600

About 60 feet below the top of the Oolite is a parting of brown argillaceous Limestone with reddish shales. Near the top *Productus reticulatus* occurs.

Above the Oolite *Lithostrotion* is abundant.

Below the Oolite the Limestones are characteristically encrinital.

The Lower Transition Beds begin near Goatchurch Cavern, in the more westerly of the Twin Brooks.

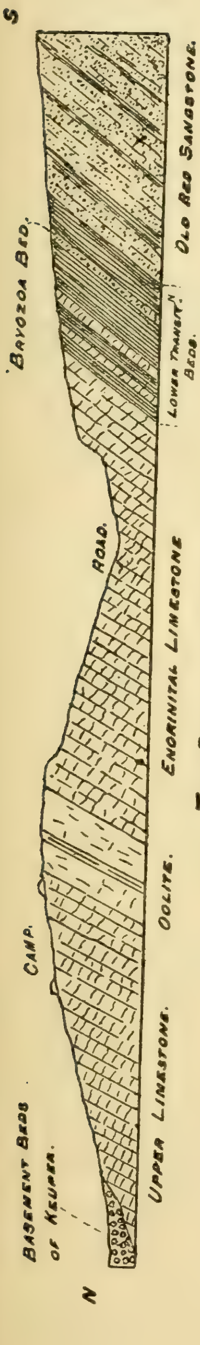
The Bryozoa Bed is found in the more easterly of the Twin Brooks just above the path connected with the rifle butts.

The Lower Transition Beds are slightly, the Lower Limestones considerably, thicker than in the Avon Section.

Notwithstanding that the upper beds of the Upper Limestone are hidden by the Basement Beds of the Trias, the total thickness of Lower Carboniferous beds *here exposed* is thicker than the total thickness of these beds at Clifton. If my estimate of the thickness of the Lower Limestone is correct, it is more than double that in the Avon Section.

LUCKINGTON.

I may here note that in a quarry in the Luckington Lime-


S
Bryozoa Bed.
Old Red Sandstone.
Lower Transit.n Beds.
Road.
Encrinital Limestone
Oolite.
Camp.
Upper Limestone.
Basement Beds of Keuper.
N

Hor.l Scale 6 in to 1 mile.
Ver.l Scale twice Hor.l

The Burrington Section along the line AB in map.

Fig. 3

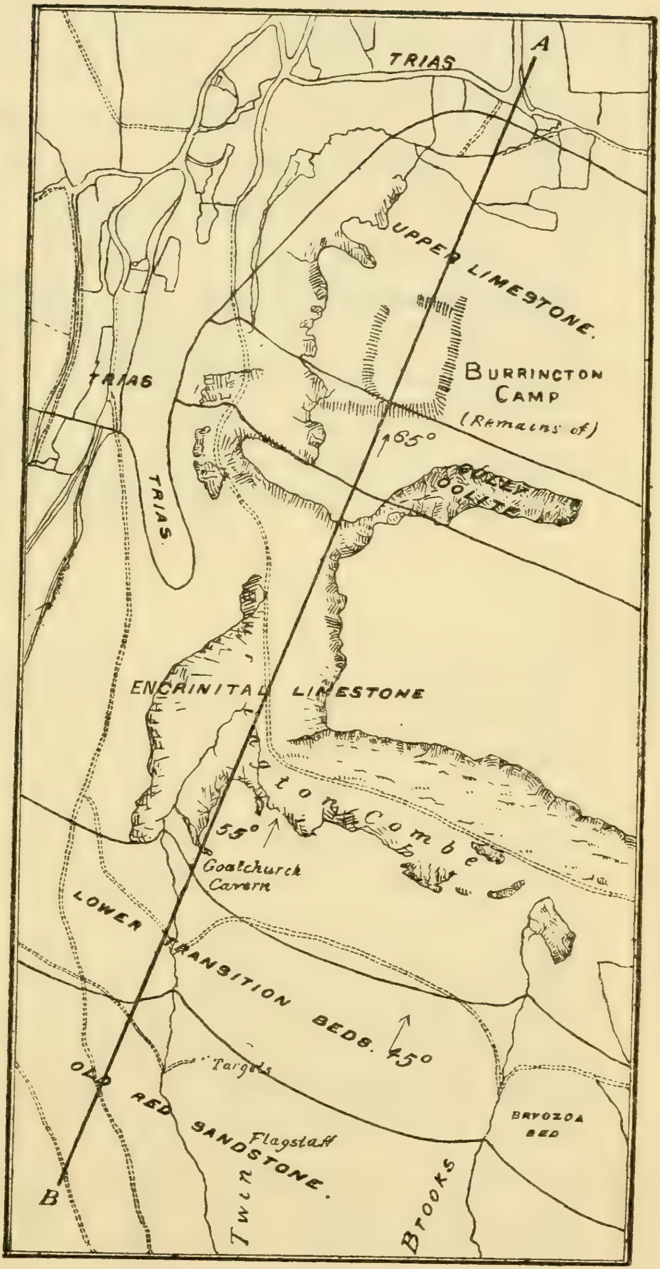

A
Trias
Upper Limestone.
Burrington Camp (Remains of)
65°
Trias
Trias
Oolite
Encrinital Limestone
gton Combe
55°
Goatchurch Cavern
Lower Transition Beds.
45°
Targets
Old Red Sandstone.
Flagstaff
Bryozoa Bed
Twin Brooks
B

Fig. 4.

Scale 6 inches to 1 mile.

stone, Mr. Winwood, Mr. McMurtrie, and I, noted black shaley beds overlying the limestone. These at first sight looked like Coal-measure Shales, but proved to be Rhœtic or Penarth Beds resting uncomformably on the Mountain Limestone. *Avicula contorta* was found; and the Bone Bed. Mr. Winwood is describing the section (with a figure) in the Proceedings of the Bath Field Club.

I cannot conclude these brief notes without saying that if I have been led to differ from the conclusions reached by the gentlemen of the Geological Survey in certain details of mapping, I do so with some diffidence and in the interest of accuracy. I yield to no one in my admiration of the work of the Survey in the Bristol and Mendip areas.

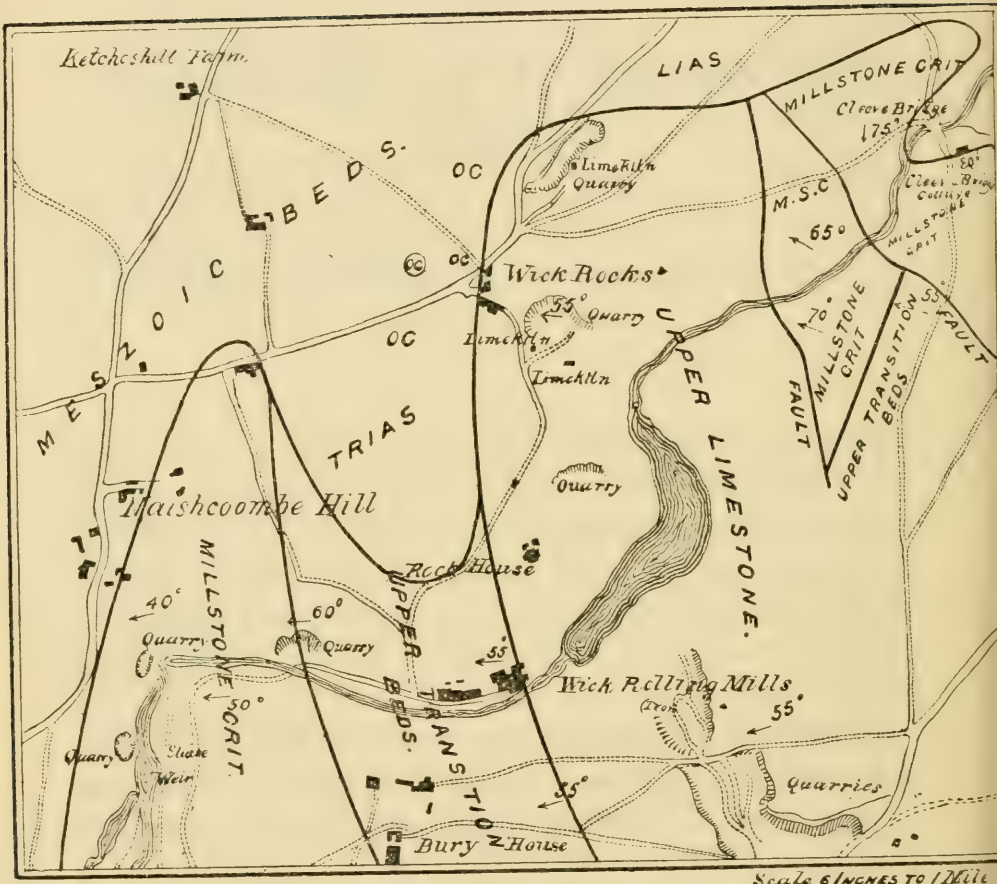
III.

The Geology of the Wick Rocks Valley.

BY PROFESSOR C. LLOYD MORGAN, F.G.S., ASSOC. R.S.M.

THE picturesque little valley near Wick, through which the little brook called the River Boyd flows, affords to the geologist an opportunity of examining an interesting little patch of Palæozoic rocks. As the geology of this locality does not seem to be well understood, I propose to supply a few notes in illustration of the accompanying sketch map.

If we enter the valley at its lower end from the Marshfield road (lower left-hand corner in the map), we see some indications of the Basement Beds of the Trias, and then find ourselves in Millstone Grit. The beds are variable. There are fissile sandstones with mica; some strong close-grained light-coloured sandstones of great hardness and durability; shales and marly beds; a bed a few inches thick which gives an excellent tough clay; and several thin but well-marked seams of coal. Beyond some indications of carboniferous plant remains, I have found no fossils, except in one


Ketcheshill Farm
LIAS
MILLSTONE GRIT
Cleeve Bridge
75°
MESOZOIC BEDS.
OC
Lime Kiln Quarry
M.S.C
65°
Cleeve Bridge Colliery
MILLSTONE GRIT
OC
Wick Rocks
55° Quarry
Lime Kiln
Lime Kiln
UPPER LIMESTONE.
70°
MILLSTONE GRIT
FAULT
UPPER TRANSITION BEDS
55°
FAULT
OC
TRIAS
Quarry
Tatshcoombe Hill
MILLSTONE GRIT.
40°
Quarry
60°
Quarry
Rock House
UPPER TRANSITION BEDS.
55
Wick Rolling Mills
Iron
55°
50°
Quarry
Sluice
Weir
Quarries
55°
Bury House

Scale 6 INCHES TO 1 *Mile*

FIG. 5.

band some crinoidal ossicles. The dip is from 40° to 50° in a direction a little (5°–10°) to the South of West.

Just beyond, where the path crosses the stream, on the north side of the little bridge, are two quarries close together (at the point marked † on the map). They should be examined carefully, since the incoming of calcareous conditions (*i.e.*, the commencement of the Upper Transition Beds are very clearly seen.

In the more westerly exposure in these quarries there is first a pebble bed, five feet thick, with milky quartz; then a foot and a half of fine close-grained grit; then another pebble bed also 1½ feet thick, followed by grits and marly shale. Between the two quarries, for they are adjacent to each other, there are 7½ feet of shale very carbonaceous, almost coal, below. Then follow twenty to twenty-five feet of solid grit, with strong pebble beds at base. These are succeeded by a bed with a curious irregularly mammillated surface. It is about one foot thick, very dense and solid, and effervesces with acid. This is the first bed with calcareous matter, and I think we may fairly regard it as the first bed of the Upper Transition series, the strong pebble bed being the base of the Millstone Grit. The calcareous bed yielded Mr. H. H. Winwood and myself two species of *Lingula*, one of which appears to be *L. parallela*.

Beneath this *Lingula* bed is a friable bed, from which the lime has been partially or completely removed by water, laden with carbonic acid soaking through. It is crowded with fossils, among which *Producta* (? *species*) is conspicuous, together with a bivalve (? *Nucula*). I hope to work out the fossils from these beds more fully. From this point onwards limestone bands, many of them richly fossiliferous, are the prevalent rock, though there are also shales and strong grit. They are the Upper Transition Beds.

I may next draw attention to the quarry just beyond the cottages, between them and the rolling mills, now used for grinding the ochre obtained from the Trias of the neighbourhood. Working from above downward, there are first about 35 feet of dark bluish-grey limestone, oolitic above, then highly bituminous. *Cyathophyllum* occurs here. This is followed by 2½ feet of grit, and then 14½ inches of red and grey marly slate. Then come twelve feet of strong dense grit, iron-stained along the joints, and this is followed by a thin coal-seam a foot or less in thickness. Beneath this is broken faulty-looking rock in which is an old adit 15 yards long—a bit of the "old men's" work. A little lower down there are a few feet of thin carbonaceous and sandy beds with thin bedded grits. These are the last sandy or gritty beds visible. Near the dam for the mill strong oolitic limestones are found, with *Cyathophyllum* and *Producta.* They are clearly Upper Limestone. The junction of Upper Transition Beds and Upper Limestone may be placed at the mill. There is no sign of a fault.

The occurrence of the thin coal-seam in the Upper Transition Beds, within 50 or 60 feet at most of the Upper Limestone, is worthy of note.

The beds have a fairly uniform dip of 55° W. The thickness of the Upper Transition Beds may thus be estimated with approximate accuracy at 600 feet.

On either side of the pond, which is dammed back for the mill, there is solid limestone, which is being worked in large quarries on both sides of the stream along the strike of the beds.

If we follow on the right hand side of the valley, still working up stream, we can scarcely fail to notice at the point indicated on the map the sudden incoming again of the Millstone Grit. This is due to a fault which runs nearly North and South (N. 10° W. to S. 10° E.). The limestone seems to dip nearly due W. The faulted-in Millstone Grit N. 70° W. The fault is undoubtedly a reversed or thrust fault, since at the upper part of the northern slope of the valley the limestone is thrust further East than it is further down the slope.

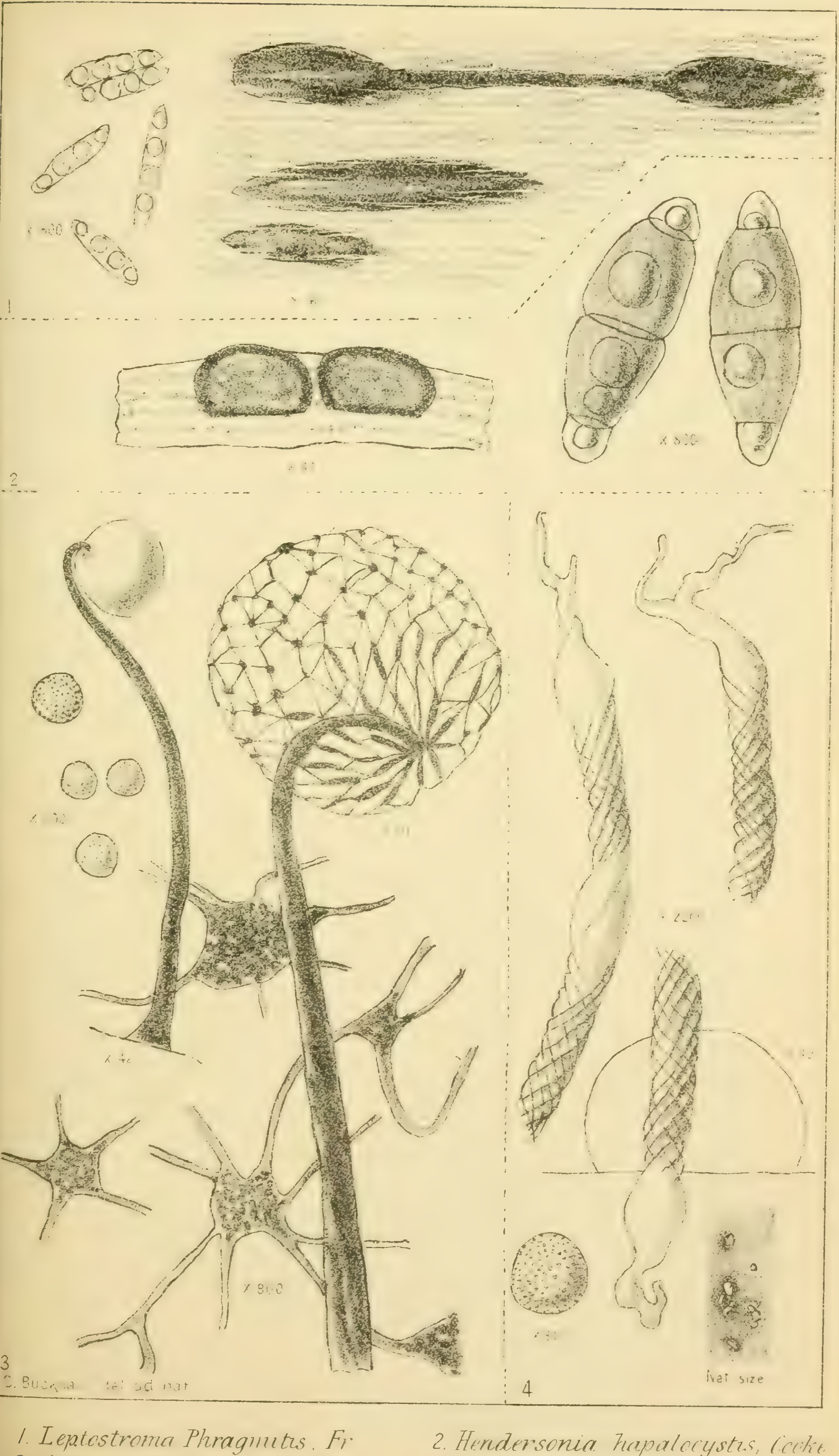
The Millstone Grit thus introduced may be followed up the stream on the southern (right hand) slope of the valley and preserves a dip of 65° in the direction N. 70° W. It is followed in due succession by calcareous beds and well-marked sandy limestones, indicating the incoming of the Upper Transition Beds which retain the same dip to N. 70° W.

Suddenly, however, we come upon strong grits, with pebble beds of milky quartz with quite a different dip, viz., 75°–80° in the direction S. 10° W. These dips are not found in an isolated patch of rock, but are seen on both sides of the stream near Cleeve Bridge. The incoming of Millstone Grit again, and that with a dip in quite a different direction, can only be accounted for by a second fault, which, according to my estimate, runs N. 30° W. to S. 30° E.

Beyond Cleeve Bridge the Palæozoic beds are covered by Trias.

The geologist, instead of retracing his steps down the valley, may take the little path from Cleeve Bridge to the Wick Rocks quarry, where he will see the Upper Limestone (in which there are strings and veinlets of Galena) well exposed.

At the points marked *o c* on the map, pits are being sunk in the Trias for ochre, which is being ground by Mr. Phipps at the Wick rolling mills. At (*o c*), for example, a bed of brown ochreous rock four feet thick was (21st June, 1890) being worked. It was about eight feet from the surface, and overlain by red (and green) marls, being underlain again by red marls.


1
× 800
2
× 800
3
× 800
× 40
4
× 200
Nat. size
C. Bucknall del. ad nat.

1. Leptostroma Phragmitis. Fr.
3. Cribaria microcarpa. Rost.

2. Hendersonia hapalocystis, Cooke
4. Trichia contorta. Rost.

The Fungi of the Bristol District.

PART XII.

By CEDRIC BUCKNALL, Mus.Bac.

THE following species are either hitherto unrecorded as British, or have occurred for the first time in Britain in this district:

1363. Agaricus (Collybia) floccipes, *Fr. Hym. Eur., p. 116. Cooke, Illus. t. 1168.*

1378. Leptostroma Phragmitis, *Fr. Sacc. Syl., Vol. III., No. 3419.* Plate I., fig. 1.

1379. Hendersonia hapalocystis, *Cooke, Grevillea, Vol. XVIII., p. 74.* Plate I., fig. 2.

1380. Cribaria microcarpa, *Rost. Mon., p. 236.* Plate I., fig. 3.

1381. Hemiarcyria Bucknalli, *Massee, Grevillea, Vol. XVIII., p. 27.* Plate II., fig. 5.

1382. Oligonema nitens, *Rost. Massee, Revis. Trich., p. 23, f. 29.*

1395. Pirottæa veneta, *Sacc. Michelia, Vol. I., p. 424* Plate II., fig. 9.

1363. Agaricus (Collybia) floccipes, *Fr. Hym. Eur., p. 116. Cooke, Illus. t. 1168.*	Leigh Woods,	July, 1889.

"Pileus rather fleshy, campanulate, then convex, umbonate, even, silky, becoming pale ; stem fistulose, straight, rooting, pallid, *rough with floccose punctiform black squamules ;* gills adnexed, ventricose, rather distant, thick, white."—*Grevillea, vol. xviii., p. 26.*

This small but interesting species was found, for the first time in Britain, in an old decayed stump in Nightingale Valley.

1364. Agaricus (Omphalia) maurus, *Fr.*	Leigh Woods,	Sept., 1889.

This and the next species occurred on the patches of ground in the Leigh Woods, where the underwood which had been cut down was burnt. The first fungi to make their appearance amongst the ashes were *Peziza melaloma* and *P. omphalodes*, and these were succeeded by an abundant crop of hundreds of specimens of *Polyporus perennis*, together with the usual inhabitants of burnt ground, *Agaricus atratus*, *A. carbonarius*, *Cantharellus carbonarius* (a single specimen), and also fine and beautiful specimens of *A. cyathiformis.*

1365. Agaricus (Omphalia) hepaticus, *Batsch.*	Leigh Woods,	Nov. 1889.
1366. Agaricus (Entoloma) sericeus, *Bull.*	Stapleton,	,, 1887.
1367. Agaricus (Pholiota) durus, *Bolton.*	Patchway,	May, 1890.
1368. Agaricus (Panæolus) caliginosus, *Jungh.*	Coombe Hill,	Oct., 1889.
1369. Coprinus domesticus, *Fr.*	Clifton (L. Rogers, Esq.),	Winter, 1890.
1370. Bolbitius Boltoni, *Fr.*	The Avon,	July, ,,
1371. Cortinarius (Phlegmacium) triumphans, *Fr.*	Leigh Woods,	Sept.–Nov., 1889.

A rare and beautiful species, and an interesting addition to our local flora. It would appear strange that such a well marked species should have so long escaped notice in this well worked locality ; but, from the resemblance of the pileus when growing to some common species of Agarics, it may easily be mistaken for them, until gathered.

1372. Cantharellus carbonarius, *A. & S.*	Leigh Woods, ,, ,,	Nov., 1889. June, 1890.
1373. Marasmius fuscopurpureus, *Fr.* (*?*).	Blaise Castle Woods,	Sept., 1885.
1374. Merulius tremellosus, *Schrad.*	Leigh Woods,	Nov., 1889.
1375. Merulius lacrymans, *Fr.*	Clifton, Bitton,	,, ,,
1376. Hydnum coralloides, *Scop.*	Sea Mills (C. K. Rudge, Esq.),	Autumn, 1888.
1377. Cyphella griseo-pallida, *Weinman.*	Clevedon,	,,
1378. Leptostroma Phragmitis, *Fr.* Plate I., fig. 1.	The Avon,	July, 1890.

"Perithecia lanceolate, rather large, 1–1½ mm. long, ½ mm. broad, distinctly rimose; spores fusoid, 15–20 × 3½ – 4 μ, 4–nucleate, curved, hyaline."—*Sacc. Syl. vol. iii., No. 3419.*

On dead stems of *Phragmites.* Saccardo, not being in possession of an authentic specimen of Fries' plant, has taken his description from specimens collected by Magnus, so that he is in doubt as to whether it is identical with that of Fries. My specimen agrees exactly with the above description, except that the perithecia are scarcely rimose. They would probably become so with more advanced age.

1379. Hendersonia hapalocystis, *Cke.* Plate I., fig. 2.	The Avon,	April, 1885.

"Perithecia scattered, immersed, scarcely visible except by cutting away the wood. Spores large, 45–50 × 18 μ, four-celled, the two median cells large, subglobose, flattened at the junction, dark brown, nearly black, ultimate cells small, hyaline, almost like an apiculus at each end. On decorticated twigs of ash, etc."—*Grevillea, vol. xviii., p. 74.*

1380. Cribaria microcarpa, *Rost.* Plate I., fig. 3. Clevedon, April, 1889.

"Sporangia globose, small, erect or cernuous, stipitate, *calyculus absent, primary ribs of network radiating from apex of stem as elongated, broad bands, anastomosing laterally, and forming elongated meshes,* passing upwards into an irregular network of very thin threads, connecting large, brown, irregularly stellate knots crowded with granules; stem slender, *elongated*, straight or flexuous, erect or curved above, brownish purple; spores globose, very pale, *minutely verruculose*, 5-7 μ diameter. *Rost. Mon., p. 236.*

Distinguished from *C. argillacea*, Pers., the only other British species without a calyculus (= the entire cup-like basal portion of sporangium), by the long slender stem, and small globose sporangium. Gregarious, 2·5-3 mm. high.

On dead Sphagnum, etc., in a stove, Claremont, Clevedon (Mr. Baker).

* Trichia contorta, *Rost. No. 1351, ante.* Plate I., fig. 4. Leigh Woods, 1881.
Yatton, Dec., 1888.

1381. Hemiarcyria Bucknalli, *Massee.* Plate II., fig. 5. Stapleton, 1880.

" Sporangia sessile on a broad or narrow base, seated on a very thin hypothallus, circular, reniform, or subangular from mutual pressure, wall very thin, gilvo-ochraceous, soon disappearing; mass of spores orange; capillitium well developed, threads combined to form a wide-meshed network, with many free ends, 4-5 μ thick, walls with annular ridges mostly crowded, but here and there scattered, and sometimes passing into a spiral, the ridges with numerous thin, straight spines 3-4 μ long, the free tips irregularly swollen and bristling with spines, as are also certain interstitial swollen portions; spores globose, pale yellow, minutely warted, 7-9 μ diameter.

Generally crowded, about ·5 mm. diameter, but extending to 1·5 mm. when isolated and elongated. Most closely allied to *H. Wigandi*, Rost., but at once distinguished by the larger size of the sporangia, the markings on the elaters being in the form of rings, and not spirals, and in being furnished with numerous spines."—*Grevillea, vol. xviii., p. 27.*

This occurred on the old beech stumps in Stapleton Park, in the year 1880, in company with *Trichia scabra*, for which, in consequence of its great external resemblance, it was mistaken, and remained undetected until last year, when, having occasion to examine microscopically the species of *Trichia* in my herbarium, the great difference in the sculpturing of the elaters in some of the specimens under the name of *T. scabra*, at once made it apparent that this belonged not only to another species, but to a different genus. Being unable to find any description to which it would correspond, I submitted my specimens to my friend Mr. George Massee, who pronounced it to be different from any species yet described.

1382. Oligonema nitens, *Rost.* Abbot's Leigh, June, 1889.

Sporangia densely crowded, often several layers superposed, sessile on a broad or slightly contracted base, *clear primrose yellow, very smooth and shining;* mass of capillitium and spores yellow; elaters scanty, variable, 4–5 μ thick, *simple or branched, perfectly smooth, or with scattered narrow rings, sometimes with an indistinct, very open spiral on the whole or portion only of an elater*, tips usually abrupt, rarely ending in a short apiculus; spores globose, *with narrow raised ridges of varying thickness, forming an irregular network*, 11–13 μ diameter. *Massee, Revis. Trich., p. 23.*

Only a single minute sporangium of this species was found. It occurred on rotten wood from a stump in the clay pits at Abbot's Leigh, and, as I know of no foreign source from which it could be derived, I feel justified in recording it as an addition to the British Myxomycetes.

1383.	Perichæna depressa, *Lib.*	Clevedon,	Nov., 1888.
1384.	Puccinia galii, *Pers.* (Teleutospores.)	Hanham,	Oct., 1888.
1385.	,, bullata, *Pers.* (Teleutospores).	Black Rock Quarry,	April, 1890.
1386.	Melampsora hypericorum, *D.C.*	Portishead Woods,	Sept., 1889.
1387.	Peziza tectoria, *Cke.*	Clevedon,	July, 1889.
1388.	Hymenoscypha tuberosa, *Bull.*	Leigh Woods,	April, 1890.

* Mollisia discolor, *Mont.*

This species, which appears to be common in the district, has been mistaken for *P. vulgaris, Fr.*, and is so recorded in *Fungi Bris. Dist., Part II.* The latter species was omitted by Mr. Phillips in the "British Discomycetes," as he had never been satisfied that he had the true species of Fries; but he has now recorded it as occurring at Shere and also at Carlisle.

1389.	Mollisia arundinacea, *D.C.*	S. Philip's Marsh,	1882.
1390.	,, palustris, *Rob. var.*, Plate II., fig. 6.	Leigh Woods,	May, 1890.

The exterior of the cup is rugose, whereas in typical *M. palustris* it is even.

1391.	Mollisia dilutella, *Fr.*	Yatton,	Jan., 1890.
1392.	Lachnella hinnulea, *B. & Br.*	Leigh Woods,	June, 1890.

On the patches of burnt ground, before referred to as producing so many species of fungi.

	* Lachnea lapidaria, *Cke. Phil. Brit. Disc., p. 211. Peziza hybrida, No. 1074 ante.* **1359 ante.* Plate II., fig. 7.	Bristol,	July, 1885.
1393.	Lachnella grisella, *Rehm. Grevillea, Vol. VIII., p. 84.* Plate II., fig. 8.	Sandy Lane,	June, 1890.
1394.	Lachnella melaxantha, *Fr.*	Leigh Woods,	March, 1890.
1395.	Pirottæa veneta, *Sacc.*, Plate II., fig. 9.	Black Rock Quarry,	June, 1885.

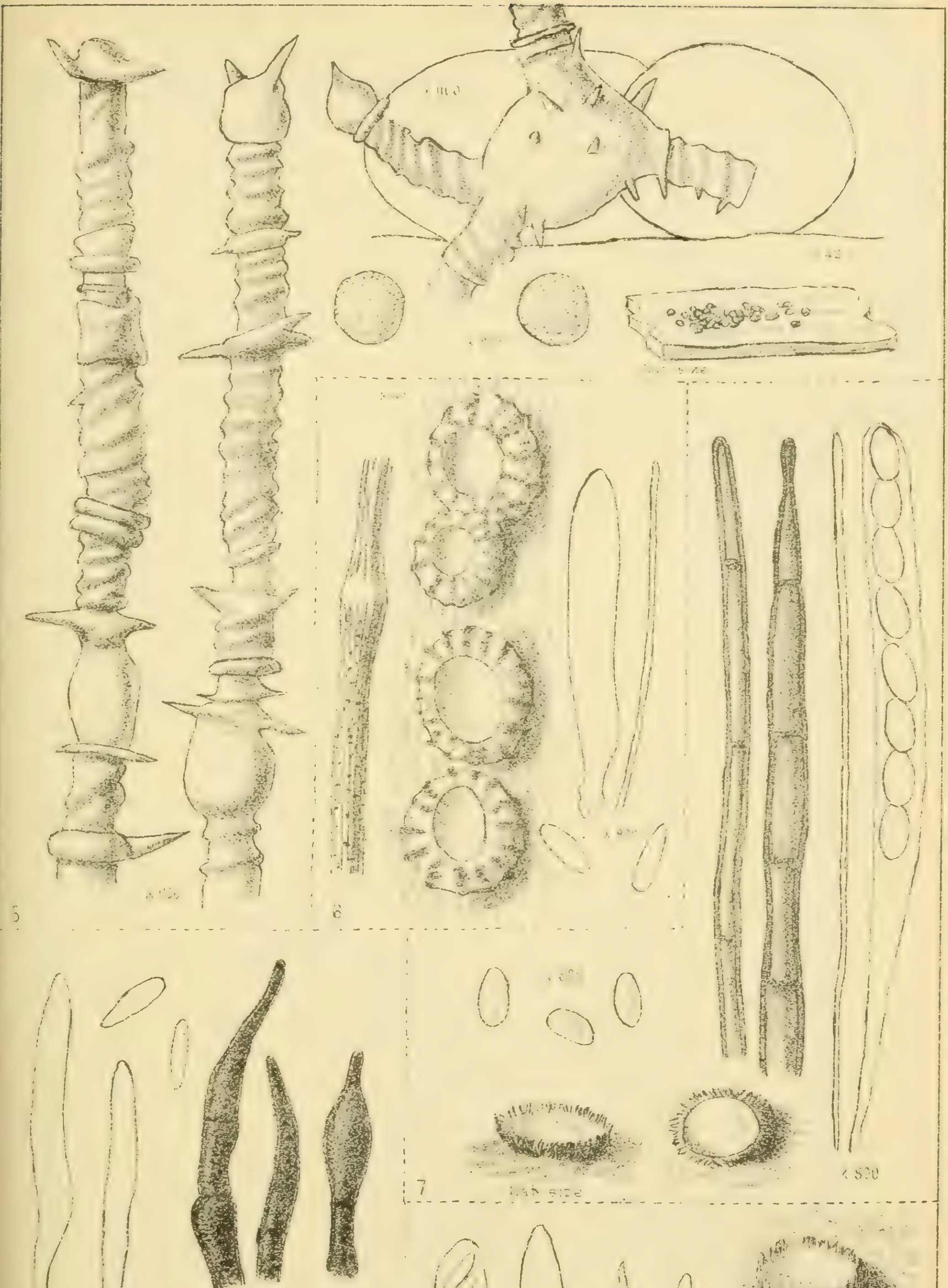
Cups sub-superficial, gregarious, scutellate, sessile, $\frac{1}{6}$–$\frac{1}{5}$ mm. diameter, black, nearly closed when dry, clothed with cuspidate, sparingly septate, dark fuligineous bristles, 40–50 × 5 μ, which are more crowded at the margin; external structure distinctly parenchymatous, cells easily separating; asci cylindraceo-clavate, 40–45 × 8, sub-obtuse at the apex, sub-sessile, 8-spored; paraphyses linear; sporidia cylindric, ends rounded, 14-15 × 2, binucleate, hyaline.

On dead stems and leaves of *Helleborus viridis*. *Saccardo, Michelia, vol. i., p. 424.*

My specimens are on dead herbaceous stems, but certainly not on Hellebore.

1396.	Hypocrea rufa, *Pers.*	Sandy Lane,	June, 1890.
1397.	Poronia punctata, *Fr.*	Clevedon,	Dec., 1889.
1398.	Ophiobolus herpotrichus, *Fr.*	Pilning,	April, 1890.
1399.	Lophiotrema semiliberum, *Desm.*	"	" "

Since the note on p. 2 was written, I have again, on June 19th, visited the patches of burnt ground in Leigh Woods, and find that they are still productive of fungi, notwithstanding the comparative dryness of the season, and the paucity of fungi in other parts of the woods. The following species were observed: *Agaricus rubescens*, *A. carbonarius*, *Cantharellus carbonarius* (several small specimens), *Polyporus perennis*, *Peziza omphalodes*, *Lachnea hemispherica*, and *L. hinnulea.*


5
6
× 800
7
nat. size
× 800
9
× 800
8
× 800
C. Bucknall del. ad nat.

5. *Hemiarcyria Bucknalli, Massee.* 6. *Mollisia palustris, Rob var.*
7. *Lachnea lapidaria, Cooke.* 8. *Lachnella grisella, Rehm.*

Rainfall at Clifton in 1889.

BY GEORGE F. BURDER, M.D., F.R.MET.SOC.

TABLE OF RAINFALL.

	1889.	Average of 37 years.	Departure from Average.	Greatest Fall in 24 Hours.		Number of Days on which ·01 in. or more fell.
				Depth.	Date.	
	Inches.	Inches.	Inches.	Inches.		
January . .	0·844	3·193	−2·349	0·203	28th	10
February .	1·538	2·258	−0·720	0·507	10th	15
March . .	4·383	2·282	+2·101	1·826	8th	15
April . . .	4·766	2·144	+2·622	0·963	7th	20
May . . .	2·687	2·413	+0·274	0·874	24th	16
June . . .	0·512	2·539	−2·027	0·262	1st	6
July . . .	4·428	3·042	+1·386	0·967	24th	14
August . .	3·328	3·423	−0·095	0·905	5th	16
September .	2·268	3·287	−1·019	0·917	23rd	9
October . .	2·264	3·612	−1·348	0·435	19th	24
November .	1·221	3·063	−1·842	0·406	24th	7
December .	2·253	2·875	−0·622	0·491	21st	16
Year . . .	30·492	34·131	−3·639	1·826	Mar. 8th	168

Remarks.—The year 1889 was on the whole a dry year. The total downfall was barely 30½ inches, against a long average of about 34 inches. The two driest months of the year were January and June, each of which showed a deficiency of over two inches. June was a splendid month, with twenty-four rainless days, and a total fall scarcely exceeding half an inch. It was the driest June recorded at this station in 37 years. The last five months of the year were all below the average, in varying degrees—August only slightly; September, October, and November considerably. From August 22nd to September 18th dry weather prevailed with little interruption. October presented the paradox of a deficient rainfall with an unusually large number of "rainy" days. The weather was very unsettled throughout the month, and the falls of rain, although seldom heavy, were very frequent. November also was somewhat inconsistent with itself. As regards the number of rainless days, it was but little behind June, and it included a period of eighteen days of almost absolute drought; yet such was the prevailing humidity of the air, that the surface of the ground was at no time completely dry.

Specially wet months in 1889 were March, April, and July —a circumstance the more noteworthy, in regard to March and April, because these months, with February, constitute, on an average, the driest portion of the year. March will be long remembered in the low-lying parts of Bristol for its disastrous floods, a repetition of which was threatened in the early part of April. In the forty-eight hours elapsing between midnight of March 6–7 and midnight of March 8–9 the downfall was about 3·2 inches; or, if we take into account the melting of the residue of a previous snow-storm, we may estimate the quantity of water to be disposed of as equivalent to 3·3 inches of rain falling in sixty hours. On the 8th of April, with portions of adjoining days, over two inches of rain fell in forty-eight hours. March was the wettest March since 1867, and April was the wettest April recorded. July was in the main a showery month, the fine weather which had prevailed in June coming to an end about July 8th. In August also the weather was for the most part broken, although the dry period at the end of the month brought the total fall below the average. On the whole, the months of July and August somewhat disappointed the hopes regarding the harvest which had been raised by the brilliant weather of June.

The only heavy falls of snow in the year occurred on February 10th, when the depth was four inches, and on March 4th, when the depth was five and a half inches. There was but little drift on either occasion.

Observations of Temperature at Clifton College, 1889.

By D. RINTOUL, M.A. Cantab.

THE outstanding facts about the temperature of the year are to be seen in the following tables. It will be noticed that the mean temperature of the year was 49·41°F., thus higher than the mean of nine years by ·37°F. This excess was mainly due to the months of April, May, June, and November. There were periods of exceptionally low temperature in the beginning of January, the last four days of February, and the first six days of March, and again in the end of November and beginning of December. The mean temperature was above the average in May and June on all but ten days.

1889 TEMPERATURES.

MONTH.	Maximum in Shade.		Minimum in Shade.		Mean in Shade.	Minimum on Ground, lowest recorded.
	Highest recorded.	Mean.	Lowest recorded.	Mean.		
January .	51·8	41·49	22·2	32·83	37·16	21·8
February .	52·1	44·01	27·5	33·92	38·96	18·2
March . .	59·2	47·40	27·3	35·61	41·50	22·0
April . .	62·3	52·20	34·1	39·95	46·07	28·2
May. . .	78·9	62·85	41·5	48·73	55·79	37·9
June . .	80·5	69·42	47·0	53·17	61·29	44·0
July. . .	77·3	68·00	49·4	54·16	61·08	44·0
August .	76·8	65·08	46·5	53·28	59·18	43·0
September	79·5	63·21	39·3	50·65	56·93	35·0
October .	60·1	53·98	35·3	43·61	48·79	33·1
November	58·0	50·91	30·5	42·53	46·72	27·0
December.	52·8	44·11	24·0	34·77	39·44	21·3
Year 1889.	80·5	55·22	22·2	43·60	49·41	18·2

Year 1888.	79·1	54·19	22·3	42·74	48·45	18·0
Year 1887.	82·8	56·0	20·4	40·9	48·4	11·7
Year 1886.	83·5	54·90	21·7	43·17	49·03	15·3
Year 1885.	87·8	53·98	22·1	42·53	48·09	20·1
Year 1884.	87·5	57·44	22·6	44·07	50·66	23·7
Year 1883.	82·5	54·54	20·9	42·88	48·71	19·3
Year 1882.	78·5	55·46	21·9	43·62	49·54	20·6
Year 1881.	86·9	55·44	12·3	42·92	49·18	5·8

MONTH.	Number of Days on which the Minimum Ground Temperature was below 32°F.	Number of Days on which the Minimum Air Temperature was below 32°F.	Number of Days on which the Maximum Air Temperature was below 32°F.	Number of Days on which the Mean Air Temperature was below 32°F.
January . .	23	10	3	5
February . .	17	11	0	0
March . . .	18	8	1	2
April . . .	4	0	0	0
May . . .	0	0	0	0
June . . .	0	0	0	0
July . . .	0	0	0	0
August . .	0	0	0	0
September .	0	0	0	0
October . .	0	0	0	0
November .	5	3	0	0
December .	21	13	1	5
Year 1889 .	88	45	5	12

Year 1888 .	93	60	2	16
Year 1887 .	148	63	2	11
Year 1886 .	102	64	1	22
Year 1885 .	68	40	1	6
Year 1884 .	51	19	0	1
Year 1883 .	79	40	0	6
Year 1882 .	63	26	2	7
Year 1881 .	94	60	11	24

MEAN SHADE TEMPERATURES OF THE MONTHS.

MONTH.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	Mean of Eight Years.
January . .	31·8	40·7	42·3	44·2	38·7	35·5	41·5	38·5	37·16	38·93
February .	39·3	42·6	43·3	42·3	44·0	35·8	41·0	36·1	38·96	40·37
March . .	43·0	45·7	37·0	44·9	41·7	40·1	39·9	38·6	41·50	41·37
April . . .	47·3	48·8	47·5	45·1	46·7	46·4	42·2	44·1	46·07	43·79
May . . .	54·4	53·7	49·9	53·3	47·0	52·2	45·5	52·5	55·79	51·65
June . . .	56·9	56·0	57·2	59·8	58·4	58·8	62·4	57·9	61·29	58·74
July . . .	65·9	59·6	57·2	60·7	62·6	62·7	63·9	58·4	61·08	61·34
August . .	58·8	60·2	60·6	64·5	57·5	59·1	60·4	59·3	59·18	59·95
September .	56·6	53·9	55·3	59·4	54·5	58·2	53·7	57·3	56·93	56·20
October . .	46·5	50·2	49·6	48·9	45·6	52·9	46·1	48·8	48·79	48·60
November .	48·3	43·7	42·8	41·6	43·3	47·1	41·2	47·2	46·72	44·65
December .	40·8	39·8	41·4	43·1	38·8	38·6	39·9	42·7	39·44	40·49
The Year .	49·2	49·5	48·7	50·7	48·1	49·0	48·4	48·45	49·41	49·04

Observations on a Pair of Blackbirds.

BY H. PERCY LEONARD.

Read February 6th, 1890.

THE paper which I have the honour of reading before you to-night will consist for the most part of observations which I have made on a pair of blackbirds which have for a twelvemonth past haunted our back garden.

I cannot chronicle anything new or striking with regard to the habits of these birds, but I have thought that a truthful account of "the short and simple annals" of the blackbird might be of interest to the Society.

There are several reasons which induce the blackbirds to leave the open country and to frequent the neighbourhood of human habitations.

The country blackbird is in constant jeopardy from the sparrow-hawk; and though I have on two occasions seen this bird in the neighbourhood of Redland, it is of rare occurrence in the suburbs of a town.

Then in the nesting season the magpie and jay are frequently successful in stealing the eggs and the young, and from these tyrants man's presence is a protection.

In summer the birds find the fruit-trees an attraction, and the slugs and snails are more abundant in well watered gardens than in the scorched hedgerows of the country; while in the winter season the evergreens in the shrubberies form a protection from the wind, and the bacon rinds and bread crumbs show a decided advantage over the famine which prevails in rural districts.

I must now introduce my characters. In accordance with the rules of polite society, I shall take the hen bird first, and simply state that she is quite an ordinary specimen of *turdus merula*, and is of course brown, and not jet black like her mate. The cock bird is however distinguished from the rest of his species, and is I believe quite a public character in Clifton; he is none other than the white-headed blackbird probably known to many of you by sight. The sides of his head are pure white, and he has besides white spots near the base of the tail. White and pied specimens occur not infrequently, and in a district near Paris they are numerous, the title to a certain estate being kept up by the annual presentation of a white blackbird to the lord of the manor. This phenomenon is known to science by the name of "albinism." In the Museum of Natural History, South Kensington, will be found a case quite filled by albinos, a white kangaroo, a white jackdaw, a white sparrow, and many other creatures who, for some obscure reason, were not able to supply colouring matter for their feathers or hair, and in consequence could not grow coloured coverings like the rest of their kind.

Besides natural albinism there is artificial albinism. When from any cause the lower cells of the skin which contain the pigment are destroyed, they are never replaced; and though the external layers of the skin which produce the hair are renewed, they, being deprived of the colouring matter, are white. This explains the white spots so frequently to be seen on a horse's back; the harness in time past has fretted the skin and made a sore place, the colouring cells once destroyed are not renewed, and though the hair grows again, it grows white. A scar on a negro is white from the same cause.

But to return to the blackbirds. About the end of February I began to notice a hen blackbird frequenting a corner of the garden where a laurustinus, an aucuba, a lilac, and a walnut tree form a small shrubbery. My suspicions were aroused, but not till I saw her one morning disappear into the bushes with a tuft of root fibres in her beak did I feel sure that she had decided to build in our domain.

On the 13th day of March I discovered a substantial foundation of a nest about four feet from the ground, lodged in a forked branch of the laurustinus; but the bird was very dilatory over the business, and the work made slow progress, her movements exactly resembling those of a labourer who is paid by time and not by the piece. It is possible however that the dry east wind which prevailed at the time had made it difficult to procure soft mud, so necessary for lining the interior.

She almost always approached the nest by a circuitous route, and with an easy *nonchalance*, assumed for the purpose of not attracting attention.

She evinced a strong dislike to other birds building in her vicinity, and but for her unneighbourly behaviour, I had hopes of a robin's and a thrush's nest in addition to her own. I observed her on one occasion viciously eject a thrush who had secured an eligible building site in a yellow jasmine trained against the wall.

On March the 22nd she was sitting close most of the day, and, anxious to find out whether she had laid an egg, I took a lantern in the evening, and went to the nest, hoping to find her "not at home." A passing breeze put out my light, and I thought I would feel my way to the nest, but, misjudging my way, I suddenly lighted on a warm fluff of feathers, and before I could withdraw my hand the bird had left the nest. I found one egg within and then retired, dreading lest my ill-timed curiosity should make her forsake the nest. Fortunately she decided to continue with us, and three more eggs were placed by the first.

On the 7th of April the occupant of the first egg broke his shell and first saw daylight, or rather would have seen it but for the fact of his being blind for the first few days of his life. His hatching took place exactly fourteen days after the laying of the egg. His example was followed at intervals by his three companions.

At this period, "Father Whitehead," as we called the cock bird, first came into prominence; somehow he kept very much in the background while the nest was in process of construction, and it was only after the young birds had made their appearance that we knew him to be the husband of the industrious little hen.

With his new responsibilities, however, he put his shoulder to the wheel, and took his part nobly in the arduous task of filling the gaping bills of the nestlings. He never sat upon the nest to keep the young ones warm, the whole of that duty devolving upon the hen; and a very necessary duty it was, considering the cold weather and the complete nakedness of the young brood.

It is somewhat hard to realise that the clumsy little creatures—naked, sprawling, and uncouth—could ever have contrived to pack themselves within the narrow compass of an egg-shell. It is explained perhaps partly by the fact that their lungs are now inflated with air, and also that their digestive apparatus is distended with food, which facts, I think, account for their increased bulk after leaving the shell.

All went well with the young family until one fateful morning when they were all four discovered dead and cold at the foot of the laurustinus bush.

The cause of this fatality is probably as follows: The walnut tree hard by the nest forms the readiest means of escape from the garden for a hunted cat, and when our terrier's desires are thus baulked, he vents his disappointment in a quick succession of ear-piercing yelps and barks. The evidence of witnesses went to prove that a cat used this means of escape early that morning, and the dog was heard to express himself in his usual style, and these sounds so surprising, and so near, must have frightened the young birds, and in their efforts to fly away, their immature wings failed them, and they fell heavily to the ground.

One would have liked to have been able to report that the natural affections of the parents were so harrowed by this affecting circumstance that they drooped and pined away. Nothing of the sort took place; and though there may have been a passing regret, the old birds consoled themselves by blackbird philosophy, and that evening the cock was noticed singing lustily from the roof of the greenhouse. It may have been a funeral dirge, but it sounded uncommonly like a carol.

Shortly after this occurrence, the bereaved parents were seen flying in and out of an ivy-covered wall which bounds the garden on one side. They examined the whole length most carefully, and a day or two afterwards commenced a new nest on the very top of the wall, partly supported by a spray of jasmine. This new situation, if not actually in a main cat thoroughfare, was so near, and so easy of access by any passing cat, that I put up a fence on either side to keep off feline marauders. An armful of small branches, and a stone on the top to keep all steady, served the purpose very well.

Not to make this paper tedious by recording too many details, I will simply say that three out of the four eggs laid in the new nest were hatched in due course.

It was while this second brood was being reared that I noticed that when one of the parents had caught a worm destined for nursery consumption, it was always divided on the grass plot into as many portions as there were nestlings, three pieces making a much more compact parcel than a length of wriggling worm.

I remember one afternoon we had a very severe hailstorm, the ground being covered to a depth of nearly half an inch. and as soon as the fall had ceased I hurried home to see how the weather had affected my friends. To my relief I found the nest warm and dry; no doubt the faithful hen had covered her defenceless brood, and had braved the fury of the pelting hail.

I have sometimes watched until the cock had flown to feed the young ones, and have then climbed a pair of steps and looked into the nest to see if he ever sat upon them. I always found him standing quite still on the edge of the nest, anxiously looking up at me to see whether he was noticed. About this time it broke in upon the mind of Father Whitehead that we had no wish to injure him or his family, and he became very tame: he would sometimes sit upon the bough of an arbutus shrub, and allow us to approach within a yard of him.

And now the fledgelings began to be too big for their home, and the eldest would sit outside the nest, looking down upon the strange new world in which he must so soon launch out and shift for himself. Then he left the nest never to return.

Yet he lingered about the neighbourhood, and was fed by his parents for some time longer, and was soon joined by the other two.

Their flight at first was a very clumsy performance, and they were very loath to trust themselves on the wing, and perhaps it was this fact that made them so tame. One of them hopping on the ground near my sister's feet was frightened by the approach of the terrier, and flew on to her hat for refuge.

We thought we had taken a final farewell of the family group, when the young ones were strong in flight; but early in October the whole family appeared on the lawn, Father Whitehead, the mother, and the three young birds, who had not yet moulted out into their respective plumage, and whose sex was therefore indistinguishable; but I think that I could make out on the neck of one of them a faint prophecy of a white patch inherited from his father.

I have here the nest built on the ivy-coveredwall. Root-fibres, leaves, twigs, and grass are the materials of its composition; and in the middle of the walls will be found a layer of clay as a protection from the cold wind.

There is a popular fallacy to the effect that birds live in their nests; but this is not so, the nest is merely a cradle or nursery for rearing their young ones, and when once the nestlings have flown, they never return to the place of their birth.

I have been much struck with the easy character of the blackbird's life in showery weather in the summer. In the morning he is waked by the sun and he breaks out into song, and as the light increases he redoubles his efforts and floods the air with melody. Fancy the pleasure of pouring out those flute-like notes from a tree top on a sunny morning, with the dew-spangled grass beneath and the blue vault overhead. Matins being over, he descends to the nearest plot of grass, and earns a tasty and bountiful repast by the simple exertion of pulling worms out of their burrows. The rest of the day is spent in varied pursuits—courting his mate, plundering the fruit garden, or extracting the luscious contents of snail shells. If the weather is dry and the ground parched, the worms go down deep and the snails hide themselves, and he has more difficulty over obtaining the supply of food.

In a dry east wind in early spring his lot need excite the envy of no one, the night is spent on a branch exposed to the steady blowing of the piercing wind, the dawn breaks coldly on the earth, and beneath leaden skies he breakfasts on frozen haws or holly-berries, no juicy worm or unctuous slug, and perhaps no water to drink by reason of the frost.

Those who feed the birds in winter will please note that the birds need water during frost, and that bread well soaked in hot water, and not squeezed dry is held in high esteem in feathered circles. A protracted frost is fatal to these birds, and even a comparatively short spell of cold weather will leave them so weak that they may almost be taken by the hand.

Since the autumnal moult the cock blackbird has quite changed his appearance, being much more heavily speckled with white than formerly.

We intend to use all the means in our power to encourage the pair to build on our premises this spring, and to this end we are diligent in supplying them with every dainty that will attract them. We find that grapes, chopped dates, sweetened porridge, and rotten apples are eagerly devoured, and we strew their favourite haunts with these delicacies. If we could secure an absolute immunity from cats, we should be doing much to render our garden a pleasant asylum for the birds; but something in this direction has been done by placing sticks and twigs in the paths most used by them. If our cat was young and active, I think we should fasten a bell to his neck, which, by giving notice of his approach, would make him comparatively harmless. As it is, however, he is too decrepid and feeble to be dreaded.

When the weather grows cold, and animal food becomes scarce, I intend to turn over a heap of garden refuse and expose the swarms of creeping things for the hungry birds; for I am convinced that the red berries are a very insufficient substitute for these things, and they are only eaten when the birds have no other food available. In a mild winter they are hardly eaten at all, and may be found almost untouched hanging to the boughs in spring. If it had occurred to me earlier in the year, I should have laid in a stock of snails for the winter. If snails are put into a dry place (a basket in an outhouse, for example), they will seal themselves up, and keep for over a year perfectly fresh; but now the snails are hidden away in their winter hibernation, and I must postpone this part of my scheme till next summer.

Those who have leisure will do well to study the birds from their windows, and to this end I would advise an opera glass or small telescope to be kept always at hand; I have found this very helpful.

I think I have discovered the *modus operandi* of hunting for worms. The blackbird alights on the lawn and immediately cocks his head on one side in the attitude of listening. If he hears nothing he hops high and comes down with a thud; then he quickly puts his beak into a worm burrow, and by dint of violent tugs brings his victim to the surface.

The loud hoppings were made, I believe, to frighten the worm into making some movement, and as soon as he moves, the enemy, guided by the sound, knows his whereabouts and promptly secures him. The worm would seem to be a very noiseless animal; but is it not possible that the bristles which surround each ring of his body may make a rustling sound quite loud enough to be heard a few inches off, and which guides the blackbird to his hiding-place?

During the building of the first nest, I took a piece of stout string, and cut it into six-inch lengths, and waiting until the hen bird had retired into the bushes in which her nest was placed, I strewed the ground with the pieces of string I had prepared. She presently emerged, and I was delighted to see the alacrity with which she seized upon the two nearest pieces, and neatly folding them into a small bundle, flew straightway to her nest. The remaining pieces were subsequently taken, and I afterwards found them firmly interwoven with the substance of the nest. One piece in particular I noticed, wound round a branch, and it must have materially helped in keep the structure steady on its foundations.

The hen blackbird is still a constant visitor, and has an almost daily encounter with a thrush, who pertinaciously asserts his right to hop on our back lawn. The blackbird regards him as a trespasser, and after a slight skirmish he is routed, and flies over the wall.

I regret to say that Father Whitehead has not been seen for some considerable time. He must labour under some disadvantage in comparison with those of his species less conspicuously marked, as I believe birds of prey will always prefer to chase a white bird, and thus it is possible he has fallen a prey to some hungry hawk. Possibly he may have been secured by some zealous ornithologist, and sits perched amid lichen and moss, in company with other victims of the ruthless collector.

I will conclude by saying that I believe additions to our knowledge of Natural History are more likely to be obtained by those who diligently observe and watch, than by those whose ideas of study are confined to making collections of stuffed birds and beasts, and I cannot conclude better than by quoting the words of that great apostle of patient observation —Charles Darwin—on this subject: "I gave up my gun more and more, and finally abandoned it altogether. I discovered, though unconsciously and insensibly, that the pleasure of observing and reasoning was a much higher one than that of skill and sport."

Some British Wild Bees.

HENRY A. FRANCIS, F.R.M.S.

(*Abstract.*)

IT would be too lengthy a task, in this short article, to even enumerate the distinctive characters of the two hundred and odd species of bees that are resident in our British Isles; it is therefore my purpose to touch slightly upon the more striking genera, and more especially upon those which I have had under my personal supervision.

In the year 1889 I was fortunate enough to discover, within easy range of observation, a colony of *Halictus rubicundus*, a bee which, in common with all its genus, is peculiarly brooded. Early in April the females rouse themselves from their hibernation, having been impregnated the previous autumn, and up to and through June appear in quantity; but no males are to be seen. This spring brood disappears in July, after depositing their eggs and providing for the grub. Midway in August males begin to make their appearance, and in about a fortnight are succeeded by females, who, after impregnation, retire into winter quarters.

The foregoing theory is Mr. F. Smith's, and I thought I would, with the chance given me, verify for myself the surmise. I therefore dug out some larvæ and pupæ at various times, and, allowing for a slight difference in dates, which of course is immaterial, my researches, as far as they go, seem fully to bear out his idea. It is, I believe, a unique habit, peculiar to *Halictus* and the nearly allied genus *Sphecodes*, that a solitary bee should hibernate.

The nest of this bee shows great industry on the part of the artisan. Although not a social insect in the strict sense of the word, yet it is very gregarious, one bank generally being, if the home of one, the metropolis of hundreds. The entrances to their burrows usually face the sun, and consist of a little tunnel running horizontally about five or six inches, with branch cells of an oval shape lying to the right and left of the main passage. The tunnel and cells are smoothed very carefully, and afterwards lined with a viscid secretion. Each cell is furnished with a little lump of pollen, nearly filling the cavity; and upon this, near the base of the cell, is laid the egg. The larva takes about twelve days to end its first stage, and changes into a pupa; in about five weeks from birth the imago appears, generally making its exit into the world about the end of August. It is stated that these insects burrow during bright moonlight nights; but this I did not see. I never saw them excavating during the day, but always engaged in collecting pollen.

Like many another hardworking inhabitant of this world, *Halictus* is greatly troubled with parasites which fatten at its expense, literally taking its children's bread. Such an intruder is the wasp bee, *Nomada varia*, a true cuckoo, which lays its egg on the pollen provided for the offspring of *Halictus*, and profits by that which cost her no labour. Bolder robbers, such as *Cerceris* and *Philanthus*, capture the living insects and carry them off to feed their young. A very favourite resort in the autumn for *Halictus* is the flower of the yellow ragwort, *Senecio jacobæa;* had I been murderously inclined, during one heavy wind from the south-west, I could have collected some hundreds off the heads of that plant. The genus *Halictus* is readily distinguished by the long labrum, or upper lip, of the female, and also by a curious vertical *rima* on the last segment of the abdomen.

A very common spring bee in Clifton this year is *Anthophora pilipes.* Few insects differ so much in the appearance of the sexes. The male is a yellowish-brown, with curious long hairs on the forelegs; the female a very black-bodied bee, with the tibia or shank of its hind legs covered with dark golden hairs. It is one of the burrowing bees, and is often found in considerable numbers. Mr. Walcott, of this city, captured a hermaphrodite specimen, and a second was secured by Mr. F. Smith at Barnes, in April, 1836; it is figured in his catalogue of British bees.

I now touch upon one of the most ingenious workers in this family Britain can boast of, the genus *Osmia.* It is not uncommon in this locality, one member, *O. rufa*, being rather plentiful at Stapleton. In this abstract it is only possible to instance one proof of its power of suiting its wants to its circumstances. The usual habit of *O. rufa* is to form a burrow in cliffs or decaying trees ; but should it come across an empty snail-shell in a hidden situation, it, finding a cavity ready made, promptly seizes the opportunity, and forms its cells within it.

An allied genus, *Megachile*, is also found very plentifully in this locality, and is popularly known as the leaf-cutter bee, from its habit of cutting out pieces from rose leaves or other plants for the purpose of lining its cells.

A very favourite plant this spring with the *Andrenidæ* and the hive bee is the wood spurge, *Euphorbia amygdaloides.*

A list of bees found this year by me in the vicinity of Bristol up to the first week in June (weather not very suitable for the tribe) may be of interest to local hymenopterists, and with that I will conclude this brief epitome of my paper:—*Bombus hortorum*, *B. terrestris*, *B. virginalis*, *B. lapidarius*, *Andrena albicans*, *A. nitida*, *A. atriceps*, *Osmia rufa*, *Anthophora pilipes*, and *Psithyrus vestalis*—the last suspiciously in attendance upon *B. virginalis*. Some of the *Nomadæ* I have also noticed on the wing.

Cornish Viaducts.

By A. P. I. COTTERELL, Assoc. M.Inst.C.E.
Read Tuesday, January 21st, 1890.

THE Cornwall Railway, which extends from Plymouth to Falmouth for a distance of 66 miles, was opened in 1859 as a broad-gauge single line, though most of the bridges were built to eventually accommodate a double line of broad gauge. The West Cornwall Railway, which joins the Cornwall line at Truro, and extends to Penzance, was opened in sections. It was originally a narrow-gauge single line only; but when the Great Western Railway bought it up, they laid down a third broad-gauge rail throughout, so that it is now a mixed gauge. As might be expected from the hilly nature of the country, the Cornish lines are anything but flat. Steep gradients follow one another almost without intermission, and sometimes continue for miles. In the Glynn Valley, between Bodmin and Liskeard, the line rises at the rate of 1 in 60 to a height of about 450 feet, gradually ascending from the level of the River Fowey, till it reaches the top of the hills and disappears over the ridge. As it rises it crosses numbers of side ravines, some deep and some shallow, which are mostly spanned by viaducts, there being of these no less than seven in a distance of four miles.

There were originally forty-two viaducts in the 66 miles on the Cornwall Railway between Plymouth and Falmouth, exclusive of Saltash Bridge ; and their total length amounted to about 4¾ miles. On the West Cornwall Railway, between Truro and Penzance, the viaducts are ten in number.

All the old viaducts were constructed for a line of single broad, and measured, as a rule, 14 feet between the parapets, a width that would never be tolerated by the Board of Trade now-a-days. Some of these were constructed entirely of timber; but the greater number consist of masonry piers, from the tops of which timber struts radiate and support the beams which carry the decking. They were designed by the great Brunel, and although they are unfortunately built of such a perishable material as wood, they are beautifully proportioned to the work they have to do. Doubtless the immense cost of the railway, amounting to £30,000 per mile,—a very large sum for a single line in those days—precluded him from using anything more durable. The wooden viaducts of course require continual watching and constant renewals, which become proportionately greater and greater the older that they grow. The timber used in their construction and subsequent renewal is Quebec yellow pine, treated with Kyan's process, *i.e.* soaked in a solution of corrosive sublimate. This process will preserve the wood very fairly, provided it be in a dry situation, although it fails under water, and the corrosive sublimate is apt to volatilise. Kyanising was preferred to creosoting on account of the liability of creosoted timbers to catch fire from the sparks of a passing engine. As it is, a large tub of water is placed at each end of the viaduct, in which a swab is kept ready for any emergency. The platelayers keep a good look out on the viaducts; and if, after the passage of a train, they observe smoke rising from the timbers, they are instructed to run immediately for the wet swab, and beat out the fire before it has become too large to be manageable. Such cases have only occurred once or twice, however; and the tubs of water, being sunk into the ground, and as a rule overgrown with long grass, now serve to form a chilly trap for the unwary pedestrian, who unconsciously ventures near them. The average life of the timber is about eighteen years,—some more, some less.

The masonry of the piers varies very much with the locality. Some of them, those in the Glynn Valley, for instance, are admirably built; but others, such as those of the old Moorswater Viaduct, are rather poor. The stones are, as a rule, small; but this is only natural at a time when they did not have the appliances which we now possess, and had to haul all their materials up by hand or horse cranes, instead of the handy steam derrick cranes which we find so useful now-a-days. There is scarcely a straight viaduct throughout Cornwall. Doubtless this is in great measure due to the necessarily sinuous nature of a railway which has to be continually winding in order to seek the easiest ground; but the old builders seem almost to have taken especial pains to put their viaduct on the curve, when, as has been done in reconstruction, they might easily have built it on the straight.

The vibration on these viaducts as a train passes over them is something rather larger than considerable. The author himself has often been in one of the manholes which project beyond the parapet at intervals, and has never quite got over the feeling that he was going to be shot over the side of the viaduct like a stone out of a catapult.

Since 1871, fourteen of these viaducts out of the forty-two have been replaced by more durable structures. Two have been done away with altogether, one having been substituted by a high embankment, and the other by a retaining wall and bank. Ten have been replaced by masonry arched viaducts, and two, St. Pinnock and Largin, in the Glynn Valley, by iron girders with masonry piers. The total length of wooden viaducts thus renewed now amounts to about 1·2 miles. On the West Cornwall Line, out of ten viaducts seven have been rebuilt in stone and iron. All of these are built to eventually accommodate a line of double narrow gauge.

As a rule the masonry viaducts differ but little from one another. Now that nearly all the higher ones have been rebuilt, there is little cause for any distinct departure, and a standard pattern has consequently been adopted, which is preferable, not only on account of the labour saved in calculation, but also because of the immense reduction in the cost of centering, etc.

The standard arch, of which thirty-three are being or have been built upon five viaducts, averaging 90 feet mean height, has a span of 56·7 feet by 20 feet rise, the radius of intrados being 30 feet.

The piers have a batter of about 1 in 50, and are built of Westwood slate stone and quoins of granite, upon concrete bases. The arches vary in thickness from springing to crown, and also from face to centre of viaduct, the voussoirs, which are of granite, being thinner than the rubble backing behind. Jack arches fill the spandrils, and together with the arch are covered with a good coat of asphalte before the ballast is laid. The parapets are very plain, and have open spaces, protected by iron bars, left at intervals to act as manholes. With the exception of one or two of the earlier ones, all the reconstructed viaducts on the Cornwall Railway have been carried out by the Company themselves. This course was adopted in preference to the usual one of employing a contractor, as being not only much more convenient, but cheaper. The Railway Company is fortunate in possessing an excellent quarry of building stone upon their own land at Westwood, in the Glynn Valley, and are necessarily the carriers of all the materials brought upon the works. As, also, most of the viaducts do not differ materially from one another, it is plain that one well-trained gang of workmen would accomplish the work far more efficiently and expeditiously than would be the case if with every new viaduct a fresh contractor brought a new and comparatively raw set of hands upon the works. Taking these facts into consideration, they decided, after trying one or two contract viaducts, to employ a resident engineer and experienced staff of inspectors, and to place all the responsibility entirely in their hands. These remarks apply only to the Cornwall Railway. On the West Cornwall Railway the case is different. Here the new viaducts are being built under contract in the usual manner, under the supervision of the resident engineer.

For a fuller consideration of the various types of new viaducts, I propose to select three—Moorswater, Bolitho, and St. Pinnock—as fairly representing the different styles of reconstruction.

Moorswater is the largest viaduct on the line, being no less than 320 yards long, and 147 feet high. This noble structure consists mainly of eight segmental arches, in spans of 80 feet, with a rise of 32 feet, and springing from an average height of 90 feet above the ground. It has a little more ornament displayed upon it in the way of string course, etc., than has fallen to the lot of subsequent viaducts, and altogether forms one of the finest structures to be seen in the West of England. Moorswater was originally intended to be built by contract, but was finally withdrawn and built by the Company themselves, at a cost, it is stated, of

£32,000. It was commenced in April, 1878, and completed and opened for traffic in Feb., 1881.

The new Moorswater Viaduct, and in fact all the early viaducts, were designed by Mr. H. J. Cole, of the Great Western Office, Plymouth, who also acted as resident engineer upon the works under Mr. P. J. Margary, M. Inst. C.E., chief engineer of the Cornwall Railway. The new viaduct is built alongside the old one, and is quite straight, with the exception of a curve of 1,440 feet radius at its western end.

A good foundation for the piers was found upon the slate rock at an average depth of about 12 feet below the surface. The excavations were then filled up with Portland cement concrete to the level of the ground, forming an even base upon which to build the piers. This concrete was mixed in the following proportions :—1 measure of Portland cement, 3 of sand, and 3 of clean broken granite of the size of road metalling, and here and there large granite spawls were imbedded in the proportion of ½ ton to 1 ton of concrete.

Two kinds of stone were used at Moorswater. For the quoins, voussoirs, string courses, and other ornamental work, granite from the Cheesewring and Luxulyan quarries was employed. The remainder, and by far the larger proportion of stone, was obtained from the Westwood quarry, and conveyed by special stone train to the top of the bank. From there it was lowered to the bottom by means of an inclined plane, on which the full descending truck pulled up the empty one. This stone is stated to be "a slate rock intersected with veins of carbonate of lime. The general colour is blue, like roofing slate, with white veins. It has a first-rate natural bed, and throughout the works was used in blocks up to 2½ tons weight."

The mortar consisted of blue lias lime mixed with sea sand and furnace ashes in the proportion of 1 of lime to $1\frac{1}{2}$ of sand and $\frac{1}{2}$ of ashes, and ground with water in a steam mortar-mill. The average tenacity of this mortar was found to be 70 lbs. per square inch, twenty-eight days after mixing.

The piers had not progressed very far when an accident occurred, which involved the death of the resident engineer, Mr. H. J. Cole. To unload the stone trains from the quarry, a small travelling crane was used, kept on a siding on the top of the bank. These cranes are generally provided with clamps to tie them down to the rails when a heavy weight is being lifted. By some means or other these clamps were not, or could not be, used, and upon the arrival of the stone train, the driver was unloading so slowly, that the resident engineer became impatient, and jumped upon the crane to show the driver how he wanted it done. In lifting a heavy stone, however, he upset the crane, which, falling upon him, crushed and scalded him to death instantly, and so injured the driver that the poor fellow died a few days after.

Mr. Cole was succeeded by Mr. T. H. Gibbons, M. Inst. C.E., who has carried out the construction of all the subsequent viaducts, and fortunately, on those built by the Company themselves, without the loss of a single man. Accidents have, of course, been numerous, one man having fallen from a height of 60 feet; but when the extremely risky nature of the work is considered, it is certainly remarkable that the casualties have not been more numerous.

The piers are intended to diminish with an even batter of 1 in 60 on all sides. As a matter of fact they do not quite do this, it being discovered when nearly up to the springing that the face had set out all the way round, thus making the inclination steeper. This seems to be due to a greater settlement of the outside stones, which it does not appear possible to avoid, and as difficult to properly account for. It has since been obviated by working the batter to say 1 in 57 instead of 1 in 60. I need hardly say that these piers, as well as abutments, are magnificently built. The stones are splendidly bedded and bonded together, without a sign of that abominable scamping which so often ruins well-designed work.

It was, of course, impossible to use an overhead way in building these piers, on account of their great height, and it would have been equally absurd to use scaffolding. Steam derrick cranes were therefore employed, provided with 70 feet jibs, and capable of lifting a weight of 3 tons. These were placed on stages 70 feet above the ground, thus enabling the cranes to set stones up to 120 feet above ground level. The men were also taken on and off the work by means of cranes.

When the impost courses were set, wrought iron lattice girders, made on the ground out of old rails, were hoisted up and placed upon them. These girders were curved at the two ends to the radius of the arch, so that by means of hand cranes placed upon them, the arches and backing were built up to 10 feet above springing. The timber centres were then placed upon the girders, the weight being transmitted from the centre to the girder through sand boxes. These sand boxes were introduced for the purpose of slackening the centre more easily. When the arch was keyed, the sand was removed through a small hole in the bottom of the box, and the centre was lowered. Sand boxes were found to be preferable to slackening wedges, the objection to them being that the loosening of the wedge blocks always causes an uncomfortable jar to the work. This defect does not occur with the sand box, where the centre comes away quite easily.

Two temporary roads were constructed, one on each side of the girders, projecting beyond the face of the arch, in order to carry materials. An overhead road was also made on the top of the centre, upon which worked a hand travelling crane. By these means the remainder of each arch was finished, beginning at one end of the viaduct and proceeding in order to the other.

" Twenty-five girders were constructed for five arches out of the eight, and timber centres were provided for four arches out of the eight, so that the girder work was one bay ahead of the timber work till the last arch was reached." The abutments were also carried to the solid rock, and were built of solid masonry 20 feet thick at the base, and provided with splay wing walls, battering 1 in 3, to retain the bank.

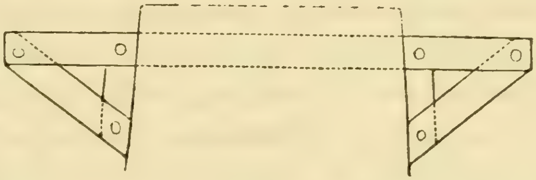
On the arches came two rows of jack arching, which brought the whole surface up to a nearly even level, a slight slope being made from piers to centre of arch to allow for drainage of water, and from these points pipes were carried through the arch to enable the water to run off. The whole of the jack arches were covered with a layer of asphalte, thus absolutely preventing water from getting in and washing out the lime from the joints, to form stalactites on the arch below. All that now remained was to finish the string course, manhole corbellings and railings, and to form the permanent way approaches on either side by means of tipped earth and dry walling. The whole viaduct was now ready to receive the ballast and rails. It was then passed by the Board of Trade, the line was diverted between the trains, and Moorswater Viaduct was opened for traffic.

Bolitho Viaduct, which was also undertaken by the Company, is 182 yards long, and 113 feet high. It was built under peculiar circumstances, on account of the Company being unable to obtain extra land without great cost. They were therefore cramped inside their own fences, and adopted the expedient of building the viaduct in two halves, diverting the line to the one half whilst they pulled down the old viaduct and built up the other. The piers were spaced so as not to interfere with the existing ones, thus enabling the whole of the concrete foundations to be laid at one time. Strips of hoop iron were left projecting all the way up the unfinished sides of the piers and abutments, and built into the second half in order to assist in bonding the two thoroughly together. This they seem to have done; for no unequal settlement of the two halves appears to have taken place, the whole viaduct being perfectly homogeneous, as if it had all been built up together.

Since Bolitho is one of the standard pattern viaducts, it may be well to detail in order the works in connection with its construction, and this explanation will apply to all the later viaducts.

The survey having been made, and the drawings prepared and approved, the extra land, if necessary, is negotiated for. The new centre line of railway is then ranged out, and the bases of the piers and abutments marked out for excavation. When the concrete is set, the centre line is again picked up, and the quoins of each pier, or abutment, as the case may be, are carefully set out with steel tape and theodolite, the four first quoin stones being set upon the spot, whilst the engineer is present.

The masonry, which is then carried up, is left with a rough rock face in "random range work." The error in batter is allowed for, as already explained, and the pier is carried up to springing by the derricks. Here the following method is adopted for supporting the centres. Wrought iron bands are built into the pier, with their thin end downwards, projecting a few feet on each side. Ordinary wooden brackets are then attached to these, and upon the struts rest the timber centres, which, unlike Moorswater, are all in one piece. Sand-boxes are again used to transmit the weight of the centre.

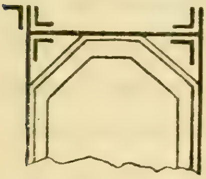


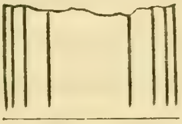
The advantage of this double bracket is that the weights of two centres, or rather of their superincumbent unfinished arches, are transmitted evenly on to the pier without tending to pull it over. Also that very little material is wasted, since all the timber struts come in for use again, the wrought iron only been left behind, sawn off close to the pier. Generally four arches are centred at a time. Before striking one set of centres, two arches are keyed, the third centre is rather more than half, and the fourth centre about a quarter, covered. In these unfinished arches, the side nearest the arch whose centres are to be slackened, is built about $5\frac{1}{2}$ feet farther up the centre than the opposite side. By thus averaging the heights of the various portions of the arches, the horizontal pressure arising from the first arch when slackened is gradually reduced to a minimum, and does not damage the piers. The overhead way, with its travelling crane, is brought into use as soon as possible, and continued over each arch as the centering proceeds. The remainder of the work is then similar to that already described at Moorswater.

St. Pinnock and Largin Viaducts differ entirely from the others. They are constructed, as already stated, of lattice iron girders on masonry raised upon the old piers. The superstructure was completely transformed in a most successful manner without endangering the safety of a single train. The traffic was not disturbed for a single day, although the very decking upon which the permanent way was laid was taken up and replaced.

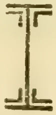
St. Pinnock Viaduct is 211 yards long, and 151 feet high, and is the loftiest viaduct on the Cornwall Railway. The masonry piers of the old viaduct, which was built for a single broad gauge, were in such good condition that it was decided to raise them 23 feet, so as to carry, outside the timber works, wrought-iron girders, with a floor of sufficient width to admit of two lines of narrow-gauge rails. It was very fortunate that the old piers admitted of this mode of construction; for to have entirely rebuilt so lofty a viaduct would have cost quite double as much as what it eventually came to. St Pinnock Viaduct consists of eight central spans of 66 feet (centre to centre of piers), and two short end ones of 50 feet. It was renewed by the Company themselves, and was opened for traffic in 1882.

The general course of alterations can be described as follows: Temporary ways were first of all constructed on baulks projecting from the viaduct on both sides, in order to balance. Small hand cranes worked upon them, and by these means the piers were built up to the required level. The advantage of these temporary ways was that the main line was thus kept perfectly clear. Whilst raising the piers the timber struts had, of course, to be interfered with as little as possible, or the whole viaduct might have come down. For this purpose a large arched opening was left in the centre of pier and the inner struts were drawn into it. The outer struts which could not be moved were built round and drawn out afterwards. The diagonal bracing was removed to the inner struts. On the new tops of the piers large bed stones for the main girders were set. These stones were each five tons in weight, and were lowered by a travelling crane from the main line of railway. The piers were then ready to receive the iron work. This consisted primarily of two main lattice girders to each span, each weighing fifteen tons, 66 feet long, and 9 feet high, placed 16 feet apart. They were of a somewhat box-latticed construction, the top and bottom booms being of this form,





and the verticals thus (like the web of an ordinary girde



with bar diagonals of various widths. The lower boom was therefore quite hollow, but was provided with a bearing-plate, where it rested on the bed stones. The cross girders, which were ordinary plate girders, were attached to the verticals about half-way up, being strutted also from the main girders by means of T bars. Upon them came the longitudinal rail girders, which, together with the main girders, carried the decking. This consisted of Barlow rails laid side by side. The girders were built by contract, at Cheltenham, and sent down to the Westwood quarry, which is close at hand, on a special truck. From the siding the main girders were taken out as required, hanging from the ends of two 10-ton travelling cranes drawn along by a locomotive. They were then swung over the side of the old viaduct and lowered into place. "Two girders have been thus fetched from the siding one after another, brought out to the viaduct, lowered into place, and the cranes put back in the siding in less than an hour." In a letter the author received the other day from the resident engineer, he mentioned that they were taking a main girder out to Largin Viaduct that very afternoon. The large girders having being placed, the cross girders were brought out by the main-line travelling crane, and deposited on the main girders near to where they were to be fixed. They were then hauled up into position, and rivetted to the main girder without interfering with the main line.

The little rail girders were then lowered through the floor of the viaduct, and the weight of the decking, when they were fixed, was transferred to them. The timbers of the old viaduct, which was built on the straight, had become in some places rather warped with age, and it was found necessary to cut half through some of them before the main girders could be finally placed in position. When this was the case the girders were first placed as near as possible into exact position, the cross and rail girders were attached and made to support the decking, and the whole affair was jacked into its final resting-place in the intervals between the trains. The girders once fixed, the old decking was taken up in 10-feet lengths, and replaced with the Barlow rails. The railings were then fixed and the finishing touches given, thus completing the reconstruction.

Although the cost of renewing the viaducts has been heavy, it has been estimated that the interest, etc., on borrowed capital necessary to do the work amounts to less than the present annual cost of repairs, so heavy have they now become.

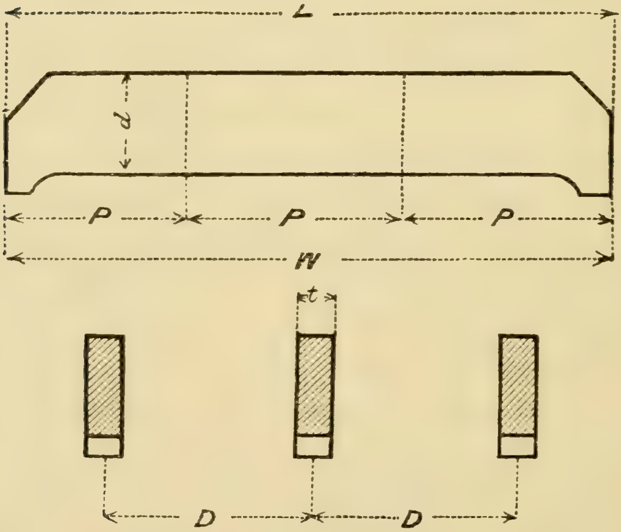
When a new viaduct is completed, the timber superstructure of the old viaduct is taken away, and in some cases the piers are demolished. As a rule, however, they are left partly standing, as not being worth the risk of removal. Thus they rather take off from the architectural effect of the new construction, which, though plain, has certainly a most substantial and satisfactory appearance. The old viaducts are certainly very picturesque, perched, as they often are, among the tree tops; but the new viaducts quite make up for all this in their increased solidity and stateliness.

In each case during reconstruction, the main line was protected by an efficient set of signals. Every care was taken to prevent accidents, and the drivers of passing trains were requested to whistle when approaching the viaduct. It is highly satisfactory, and very creditable to those concerned, to know that not only has no mishap occurred to the traffic, but that not a single train has, so far as the author is aware, been delayed any length of time in consequence of the alterations.

In conclusion, the author must mention that he is indebted to the resident engineer, Mr. T. H. Gibbons, who has most kindly provided him with many details in connection with the reconstruction of these Cornish viaducts.

Investigation of the Board of Trade's Formulæ for the Strength of Rectangular Wrought-Iron Fire-box Girder Stays.

BY J. W. I. HARVEY.



When W = width of combustion box in inches.
„ P = pitch of supporting bolts in inches.
„ D = distance between the girders from centre to centre in inches.

When L = length of girder in FEET.
" d = depth of girder in inches.
" t = thickness of girder in inches.
" c = 500 when the girder is fitted with one supporting bolt.
" c = 750 when the girder is fitted with two or three supporting bolts.
" c = 850 when the girder is fitted with four supporting bolts.

then $$\frac{c \times d^2 \times t}{(W - P) D \times L} = W.P. = \text{Working pressure.}$$

For wrought-iron the "Resistance to cross-breaking," or "Modulus of Rupture," is taken = 54,000 lbs. per square inch, when all the dimensions are expressed in inches; but as the length of the girder in the Board's Formulæ is expressed in feet,

the "Modulus of Rupture" becomes $= \frac{54{,}000}{12}$,

and the "Factor of Safety" is taken = 6.

Assuming, as is almost uniformly the case, that the supporting bolts are pitched at equal distances along the girder, so that the weights are symmetrically disposed about the centre, then the "Moment of Rupture" will be greatest at the centre of the girder; and in the case of girders with two or four supporting bolts, will be constant along that part of the girder contained between the two supporting bolts which are situated immediately on either side of the centre, so that in all cases where the above conditions obtain, it is sufficient to consider the "Moment of Rupture" at the centre of the girder which is equal to the sum of the "Moments of Rupture" produced at that point by each of the weights separately.

In a beam of this character it is not necessary to consider the "Shearing Forces," because, provided there is sufficient material to resist the "Bending Moment," there will always be an excess of material to resist the "Shearing Force."

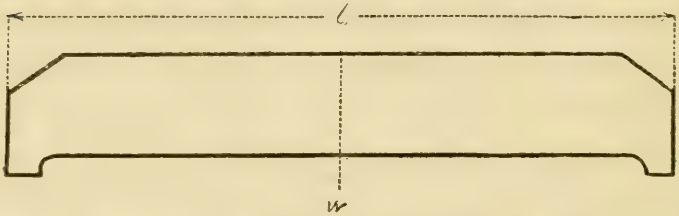
Now let us consider the four cases for which the Constant c is given in the formulæ, for girders having one, two, three or four supporting bolts respectively. And if we take

l = the length of the girder, and

w = the total weight supported by the girder,

we shall see how the "Moment of Rupture" is affected by the method of distributing the weight, and first take the case of the

GIRDER WITH ONE SUPPORTING BOLT.



Then if we take leverages about the abutments, the "Moment of Rupture" at the centre will be equal to

$$M = \frac{w \times \frac{1}{2}l \times \frac{1}{2}l}{l} =$$

$$M = \frac{w \times \frac{1}{4}l^2}{l} =$$

$$M = w \times \tfrac{1}{4}l =$$

$$M = \frac{w \times l}{4}.$$

The stability of a loaded girder depends upon the equality that must always exist between the "Moment of Rupture" $= M$, and the "Moment of Resistance" of the material $= R$. So that $M = R$.

Now for a solid rectangular girder the "Moment of

Resistance" is expressed by the equation $R = \frac{c \times d^2 \times t}{6}$, in which

c = the "Modulus of Rupture" of the material,
d = the depth of the girder,
t = the thickness of the girder.

So that taking the "Modulus of Rupture" of wrought-iron = 54,000 lbs. per square inch, we have the equation

$$M = \frac{w \times l}{4} = \frac{c \times d^2 \times t}{6} = R.$$

But as the length of the girder in the formulæ is expressed in feet, and the Factor of Safety is to be = 6, the equation becomes

$$M = \frac{w \times l}{4} = \frac{c \times d^2 \times t}{6 \times 12 \times 6} = R,$$

or, $$M = w \times l = \frac{4 \times c \times d^2 \times t}{6 \times 12 \times 6} = R.$$

And substituting the proper "Modules of Rupture" for c,

$$M = w \times l = \frac{4 \times 54000 \times d^2 \times t}{6 \times 12 \times 6} = R,$$

or, $$M = w \times l = \frac{216000 \times d^2 \times t}{432} = R,$$

or, $$M = w \times l = 500 \times d^2 \times t = R,$$

and $$w = \frac{500 \times d^2 \times t}{l}.$$

Now w = the total load on the supporting bolts, and is equal to the area of the fire-box supported by the bolts × by the working pressure; and when

P = the pitch of the supporting bolts,
W = the width of the fire-box,

D = the distance between the girders from centre to centre,
WP = the working pressure,

then $$w = (W-P) \times D \times WP,$$

and by substituting these factors for w, in the above equation we get

$$(W-P) \times D \times WP = \frac{500 \times d^2 \times t}{l},$$

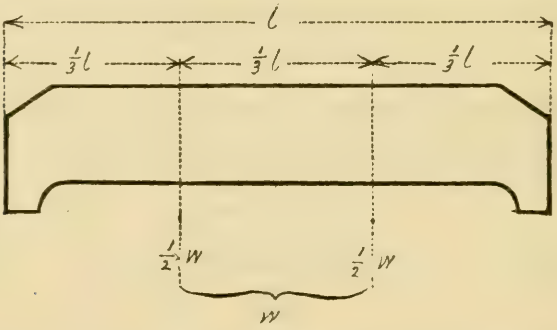
which is the Board of Trade equation,

$$\frac{500 \times d^2 \times t}{(W-P) \times D \times WP \times L},$$

in which the constant factor $c = 500$ for girders with one supporting bolt.

Next take the case of the

GIRDER WITH TWO SUPPORTING BOLTS.



Then assuming that the length of the girder and the total weight on the supporting bolts remain the same as in the first case, then the "Moment of Rupture" at the centre will be equal to

$$M = \frac{\frac{1}{2}w \times \frac{1}{3}l \times \frac{1}{2}l}{l} + \frac{\frac{1}{2}w \times \frac{1}{3}l \times \frac{1}{2}l}{l} =$$

$$M = \frac{\frac{1}{2}w \times \frac{1}{6}l^2}{l} + \frac{\frac{1}{2}w \times \frac{1}{6}l^2}{l} =$$

$$M = \frac{w \times l}{12} + \frac{w \times l}{12} =$$

$$M = \frac{2\,(w \times l)}{12} =$$

$$M = \frac{w \times l}{6}$$

Now $$M = R$$

so that

$$M = \frac{w \times l}{6} = \frac{c \times d^2 \times t}{6}$$

and in consideration that the length of the girder is expressed in feet, and that the "Factor of Safety" = 6, the equation becomes

$$M = \frac{w \times l}{6} = \frac{c \times d^2 \times t}{12 \times 6 \times 6} = R$$

or, $$M = w \times l = \frac{6 \times c \times d^2 \times t}{6 \times 12 \times 6} = R$$

And substituting the proper "Modulus of Rupture" for c,

$$M = w \times l = \frac{6 \times 54000 \times d^2 \times t}{6 \times 12 \times 6} = R$$

or, $$M = w \times l = \frac{324000 \times d^2 \times t}{432} = R$$

or, $$M = w \times l = 750 \times d^2 \times t = R$$

and $$w = \frac{750 \times d^2 \times t}{l}$$

But as before w = the total load on the supporting bolts, and as in the first case

$$w = (W - P) \times D \times WP,$$

and by substitution we get

$$(W - P) \times D \times WP = \frac{750 \times d^2 \times t}{l}$$

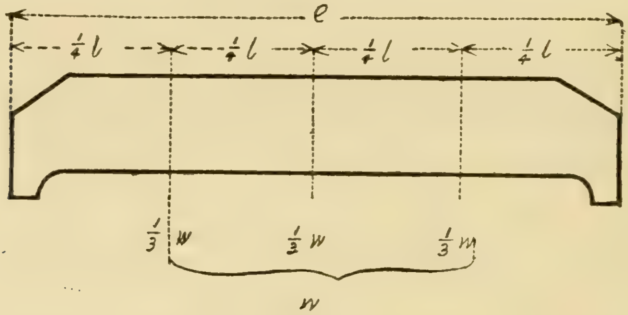
and this is the Board of Trade equation—

$$\frac{750 \times d^2 \times t}{(W - P) \times D \times WP \times L}$$

in which the constant factor $c = 750$ for girders with two supporting bolts.

Next we have the case of the

GIRDER WITH THREE SUPPORTING BOLTS.



Then assuming that the length of the girder, and the total weight supported by the bolts, remains the same as in the two previous cases, then the "Moment of Rupture" at the centre of the girder will be equal to

$$M = \frac{\frac{1}{3}w \times \frac{1}{4}l \times \frac{1}{2}l}{l} + \frac{\frac{1}{3}w \times \frac{1}{2}l \times \frac{1}{2}l}{l} + \frac{\frac{1}{3}w \times \frac{1}{4}l \times \frac{1}{2}l}{l} =$$

$$M = \frac{\frac{1}{3}w \times \frac{1}{8}l^2}{l} + \frac{\frac{1}{3}w \times \frac{1}{4}l^2}{l} + \frac{\frac{1}{3}w \times \frac{1}{8}l^2}{l} =$$

$$M = \frac{w \times l}{24} + \frac{w \times l}{12} + \frac{w \times l}{24} =$$

$$M = \frac{4\,(w \times l)}{24} =$$

$$M = \frac{w \times l}{6}$$

Note that the "Moment of Rupture" $= M$ in this case is the same as in the previous case; so that, provided that the length of the girder and the total load upon the bolts remain the same in the two cases, then the "Moment of Rupture" at the centre of the girder is the same whether two or three supporting bolts are employed.

But as before

$$M = R$$

so that

$$M = \frac{w \times l}{6} = \frac{c \times d^2 \times t}{6} = R$$

and in consideration that the length of the girder is expressed in feet and that the "Factor of Safety" = 6, the equation becomes

$$M = \frac{w \times l}{6} = \frac{c \times d^2 \times t}{6 \times 12 \times 6} = R$$

$$\text{or } M = w \times l = \frac{6 \times c \times d^2 \times t}{6 \times 12 \times 6} = R$$

and substituting the proper "Modulus of Rupture" for C.

$$M = w \times l = \frac{6 \times 54000 \times d^2 \times t}{6 \times 12 \times 6} = R$$

$$\text{or } M = w \times l = \frac{324000 \times d^2 \times t}{432} = R$$

$$\text{or } M = w \times l = 750 \times d^2 \times t = R$$

$$\text{and} \qquad w = \frac{750 \times d^2 \times t}{l}$$

But as before w = the total load on the supporting bolts and

$$w = (W - P) \times D \times WP$$

Then by substitution we get

$$(W-P) \times D \times WP = \frac{750 \times d^2 \times t}{l}$$

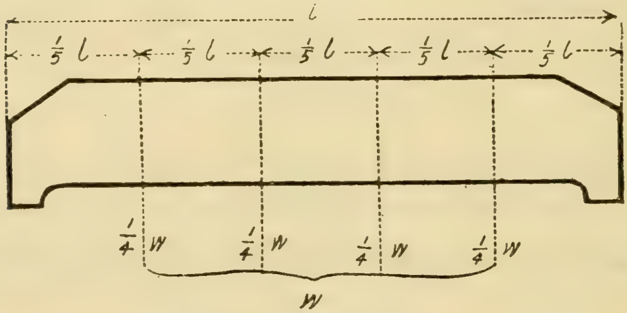
and this is the Board of Trade equation

$$\frac{750 \times d^2 \times t}{(W-P) \times D \times WP \times L}$$

in which the constant factor $c = 750$ for girders with three supporting bolts and subject to the foregoing conditions remains the same whether two or three supporting bolts are used.

And lastly we have the case of the

GIRDER WITH FOUR SUPPORTING BOLTS.



Then assuming that the length of the girder and the total weight supported by the bolts remains the same as in the previous cases, then the "Moment of Rupture" at the centre of the girder will be equal to

$$M = \frac{\frac{1}{4}w \times \frac{1}{5}l \times \frac{1}{2}l}{l} + \frac{\frac{1}{4}w \times \frac{2}{5}l \times \frac{1}{2}l}{l} + \frac{\frac{1}{4}w \times \frac{2}{5}l \times \frac{1}{2}l}{l} + \frac{\frac{1}{4}w \times \frac{1}{5}l \times \frac{1}{2}l}{l}$$

$$M = \frac{\frac{1}{4}w \times \frac{1}{10}l^2}{l} + \frac{\frac{1}{4}w \times \frac{2}{10}l^2}{l} + \frac{\frac{1}{4}w \times \frac{2}{10}l^2}{l} + \frac{\frac{1}{4}w \times \frac{1}{10}l^2}{l}$$

$$M = \frac{w \times l}{40} + \frac{w \times l}{20} + \frac{w \times l}{20} + \frac{w \times l}{40}$$

$$M = \frac{6(w \times l)}{40}$$

$$M = \frac{3(w \times l)}{20}$$

And as before

$$M = R,$$

so that

$$M = \frac{3(w \times l)}{20} = \frac{c \times d^2 \times t}{6} = R$$

And in consideration that the length of the girder is expressed in feet, and that the Factor of Safety = 6, the equation becomes

$$M = \frac{3(w \times l)}{20} = \frac{c \times d^2 \times t}{6 \times 12 \times 6} = R$$

And substituting the proper Modulus of Rupture for c,

$$M = \frac{3(w \times l)}{20} = \frac{54000 \times d^2 \times t}{6 \times 12 \times 6} = R.$$

$$M = w \times l = \frac{20 \times 54000 \times d^2 \times t}{3 \times 6 \times 12 \times 6} = R$$

$$M = w \times l = \frac{1080000 \times d^2 \times t}{1296} = R$$

$$M = w \times l = 833\cdot\dot{3} \times d^2 \times t = R$$

and

$$w = \frac{833\cdot\dot{3} \times d^2 \times t.}{l}$$

But as before w = the total load on the supporting bolts, and

$$w = (W - P) \times D \times WP,$$

and by substitution we get

$$(W - P) \times D \times WP = \frac{833\cdot\dot{3} \times d^2 \times t}{l}$$

And this is the Board of Trade equation

$$\frac{833\cdot\dot{3} \times d^2 \times t}{(W-P) \times D \times WP \times L}$$

in which the constant factor $c = 833\cdot\dot{3}$ for girders with four supporting bolts. The constant c in the Board's Rule is given as = 850. This is not strictly accurate, the exact figure is $833\cdot\dot{3}$; but the Board have adopted the constant 850 because it is a round number easily remembered and sufficiently accurate for all practical purposes.

Reports of Meetings.

GENERAL.

THE past Session has been characterised by some distinctive features in the papers read and subjects submitted to the members of the Bristol Naturalists' Society.

On Thursday, October 3rd, 1889, Mr. Cedric Bucknall, Mus.Bac., gave a *resumé* of the Fungus Foray of the Woolhope Club, and brought for inspection a large number of specimens. Professor Leipner, F.Z.S., also read a paper upon "The Dispersion of Fruits and Seeds," illustrating his address with diagrams.

The next meeting, which was held at the Victoria Rooms, Clifton, on November 7th, was one of peculiar interest, the Society having engaged Mr. Eadweard Muybridge, of the University of Pennsylvania, to deliver an address upon "Animal Locomotion in relation to Art and Design." The lecture, which was illustrated by means of the zoopraxiscope and projections by the oxy-hydrogen light, was largely attended, and the Society is to be congratulated upon a marked success.

On December 5th, Mr. Phibbs gave a paper on "Phosphorescence," treating a very interesting subject in an exhaustive manner.

The next meeting, which was held January 2nd, 1890, was by the decision of the Council devoted to the exhibition of specimens brought by various members of the Society. Mr. G. C. Griffiths, F.E.S., exhibited a collection of Lepidoptera, illustrating mimicry among that order; Mr. C. K. Rudge, a number of the boring Mollusca; Miss B. Jecks, a collection of British Birds' Eggs; Mr. H. Francis, a case of British Wild Bees; Mr. Jecks, three specimens of conglomerate (Sussex granite), vertebra and part of femur of *Iguanodon* from Wealden Clay, Volcanic Ash from the coast of Argyllshire, Glacial Drift (Lower Silurian) from North Wales, part of the Carapace of South African Land Tortoise, Carapace of the Spider Crab—*Maia Squinado*—from the Isle of Wight, teeth and part of jaw of Otter and a Crab from the Norwich Crag, teeth and part of jaw of fish from the Norfolk Chalk, and Ammonite from the Lias. Mr. H. Charbonnier showed a Bittern from Tiverton, an Albino Lark from Salisbury, a Hawfinch from Stoke Bishop, and a small collection of East Indian Crustacea. The majority of the exhibitors gave short discourses upon the several objects they had brought.

At the meeting on February 6th, Mr. G. Munro Smith read and illustrated a paper on "Muscle," and Mr. H. Percy Leonard gave the result of his "Observations on a Pair of Blackbirds," which had nested in the garden of his house, and which awoke additional interest from the fact of the male being a piebald bird. The paper is printed in the "Proceedings."

On March 6th, Dr. D. S. Davies gave an address on "Modern Methods of Disease Prevention."

The meeting on March 18th was a special one, and summoned for the purpose of hearing Mr. James McMurtrie, F.G.S., of Radstock, who had kindly consented to give a paper "On a Comparison of the Somersetshire Coal-field with the Coal Measures of Belgium and the North of France."

On April 3rd, Mr. S. H. Swayne exhibited the heads of a Gaur Bull (*Gavæus gaurus*), *Capra Megaceros*, *Capra Sibirica* or Asiatic Ibis, *Capra Bezoardica* or Black Buck, and a skin of Thibetan Snow Leopard or Ounce. Mr. H. A. Francis, F.R.M.S., then gave a lecture on "Some British Wild Bees; their Structure and Habits," illustrated by the oxy-hydrogen light.

At the May meeting, which was also the twenty-eighth annual meeting, the Report of the Council was read by the Honorary Secretary, the balance-sheet was presented, and the officers for the ensuing session were appointed. Dr. Francis Edgeworth then gave an address upon "Hypnotism," demonstrating his remarks, practically, upon the human subject. Captain Dyas sent for exhibition a set of four tusks of the Hippopotamus.

During the past session nine meetings have been held, eight at the Bristol University College, and one (Mr. E. Muybridge's) at the Victoria Rooms, Clifton.

HENRY A. FRANCIS,
Hon. Reporting Sec.

CHEMICAL AND PHYSICAL SECTION.

FOUR meetings have been held by this section during the past session, at which papers were read by the following gentlemen: Professor S. Young, Professor Ryan, Mr. Chattock, and Dr. Richardson.

The number of members and associates is 31.

ARTHUR RICHARDSON,
Hon. Sec.

GEOLOGICAL SECTION.

THE section held two meetings. At the first, the President gave some account of his investigation into the geology of the St. David's district, the results of which are published in the *Quarterly Journal of the Geological Society* for May, 1890. He also briefly described the Brislington cutting between Bristol and Bath on the Great Western Railway.

At the second meeting the President exhibited and illustrated the use of a rock-section cutting or lapidary machine, and showed slides of oolitic limestone, and St. David's igneous rocks. He also exhibited sections of Mountain Limestone chert, showing crystalline, chalcedonic, and amorphous silica. Crinoidal ossicles and other fossils converted into white silica were also shown; and Professor Lloyd Morgan explained that he had obtained them by treating the limestone of Fore Hill quarry, Portishead, with dilute acid. The limestone dissolves, and the silicified ossicles remain. A similar limestone with similar ossicles is found on Denny Island.

Two excursions were made. The first was to Ebbor, near Wookey. Professor Lloyd Morgan explained the geology of the Ebbor Valley, and briefly described the geology of Emborrow. The substance of his remarks will be found in the Mendip Notes on a previous page.

The second excursion was to the railway cutting (by the courteous permission of the authorities of the Midland Railway Company) between Tytherington and Thornbury. The President explained the geology as described in his paper in the last number of the Proceedings.

A third excursion was planned to Burrington Combe and Cheddar, but had to be abandoned owing to heavy rain.

ENGINEERING SECTION.

IN the session 1889–90, seven meetings were held.

The following papers were read: "An Investigation of the Board of Trade Formulæ for Strength of Fire-box Girder Stays," Mr. J. W. I. Harvey (Vice-President); "The Transmission of Power, with special reference to Friction-clutches," Mr. E. Shaw; "The Severn Tunnel, with some further Points of Detail" (two papers), Mr. Charles Richardson (President); "The Reconstruction of Viaducts on the Cornwall Railway," Mr. A. P. I. Cotterell; "Hydraulic Propulsion, with special reference to the Hydraulic Railway at the Paris Exhibition of 1889, Professor D. C. Selman; "The Expansive Use of Steam," Mr. G. A. Newall.

An excursion took place on June 15th, 1889, to the Barry Docks. About thirty-five members and friends attended. On arrival at Cadoxton, the party proceeded under the charge of Mr. A. Hood, Director of the Barry Docks, and Mr. E. D. Jones, Engineer to the Contractor, to the Docks, where Mr. Evans, General Manager, and Mr. John Robinson, Resident Engineer, joined the party, who were taken round the works in brake vans. The President expressed the thanks of the visitors to the gentlemen who had so kindly conducted them.

NICHOLAS WATTS,
Hon. Sec.

The following Publications of the Bristol Naturalists' Society may be obtained either from Messrs. Fawn & Son, Royal Promenade, Bristol, or from the Honorary Secretary.

Proceedings, NEW SERIES.	Vol. I.,	Part	1, 1873–74.	4*s*.
	,, ,,	,,	2, 1874–75.	5*s*.
	,, ,,	,,	3, 1875–76.	4*s*. 6*d*.
	,, II.,	,,	1, 1876–77.	3*s*. 6*d*.
	,, ,,	,,	2, 1877–78.	3*s*. 6*d*.
	,, ,,	,,	3, 1878–79.	3*s*. 6*d*.
	,, III.,	,,	1, 1879–80.	3*s*. 6*d*.
	,, ,,	,,	2, 1880–81.	3*s*. 6*d*.
	,, ,,	,,	3, 1881–82.	3*s*. 6*d*.
	,, IV.,	,,	1, 1882–83.	3*s*. 6*d*.
	,, ,,	,,	2, 1883–84.	3*s*. 6*d*.
	,, ,,	,,	3, 1884–85.	3*s*. 6*d*.
	,, V.,	,,	1, 1885–86.	4*s*.
	,, ,,	,,	2, 1886–87.	5*s*. 6*d*.
	,, ,,	,,	3, 1887–88.	5*s*.
	,, VI.,	,,	1, 1888–89.	4*s*.

Flora of the Bristol Coal-Field. By JAMES WALTER WHITE. One vol. bound. 6*s*.

The Fungi of the Bristol District. By CEDRIC BUCKNALL, Mus. Bac.

Part IV.	Species	690 to 836.	4 plates, 3 coloured, 1 black.	1*s*. 6*d*.
,, V.	,,	837 to 934.	2 ,, 1 ,, ...	1*s*.
,, VI.	,,	935 to 1023.	1 plate, black	1*s*.
,, VII.	,,	1024 to 1084.	. . . .	6*d*.
,, VIII.	,,	1085 to 1144.	3 plates, coloured	1*s*. 6*d*.
,, IX.	,,	1145 to 1240.	4 plates	1*s*.
,, X.	,,	1241 to 1321.	4 plates	1*s*.
,, XI.	,,	1322 to 1362 .	. . . .	6*d*.

On the Newly-Discovered Phenomenon of Apospory in Ferns. By CHARLES T. DRUERY, F.L.S. Illustrated. 1*s*.

Contributions to the Geology of the Avon Basin. By Prof. LLOYD MORGAN, F.G.S. I. "Sub-Aerial Denudation and the Avon Gorge." Coloured Map. II. "The Millstone Grit at Long Ashton, Somerset." With Map. 1*s*.

III. "The Portbury and Clapton District." IV. "On the Geology of Portishead." 2 coloured maps and 2 plates. 1*s*. 6*d*.

Sleep and Dreams. By GEORGE MUNRO SMITH, L.R.C.P. Lond., M.R.C.S. 2 plates. 1*s*.

The Bone-Cave or Fissure of Durdham Down. By E. WILSON, F.G.S., Curator of the Bristol Museum. 2 plates. 1*s*.

Notes on a Common Fin Whale, lately stranded in the Bristol Channel. By E. WILSON, F.G.S., Curator of the Bristol Museum. Photograph. 1*s*.

The Severn Tunnel. By CHARLES RICHARDSON, C.E., and Notes on the Geology of the Section by Prof. LLOYD MORGAN, F.G.S. With geologically coloured Section of Tunnel, map and plate. 2*s*.

The Mendips: A Geological Reverie. By Prof. C. LLOYD MORGAN, F.G.S. 1*s*.

The Arch. By CHARLES RICHARDSON, C.E., with illustrations. 1*s*.

ADOLPH LEIPNER, HON. SEC.

47, HAMPTON PARK, CLIFTON.

NEW SERIES, Vol. VI., Part III. (1890–91). Price 4s. 6d.

PROCEEDINGS
OF THE
BRISTOL
NATURALISTS' SOCIETY.

EDITED BY THE HONORARY SECRETARY.

BRISTOL NATURALISTS' SOCIETY

"*Rerum cognoscere causas.*"—Virgil.

BRISTOL:

Printed for the Society.

MDCCCXCI.

NEW SERIES, Vol. VI., Part III. (1890–91). Price 4s. 6d.

PROCEEDINGS
OF THE
BRISTOL
NATURALISTS' SOCIETY.

EDITED BY THE HONORARY SECRETARY.

BRISTOL NATURALISTS' SOCIETY.

"*Rerum cognoscere causas.*"—VIRGIL.

BRISTOL:

PRINTED FOR THE SOCIETY.

MDCCCXCI.

TABLE OF CONTENTS.

NEW SERIES, VOL. VI., PART III.

PAGE

Portrait and Obituary Notice of Mr. William Sanders, F.R.S.

The Nature and Origin of Variations. Presidential Address by Prof. C. Lloyd Morgan 249

Bristol Fungi. Part XIII. By Cedric Bucknall, Mus.Bac. . 274

Phenological Observations for 1890 278

Rainfall at Clifton, 1890. By George F. Burder, M.D., F.R. Met.Soc. 287

Observations of Temperature at Clifton, 1890. By D. Rintoul, M.A. Cantab. 290

The Frosts of Recent Years. By George F. Burder, M.D., F.R.Met.Soc. 294

Landslips. By Charles Richardson, C.E. 301

Some of the Water-bearing Strata, and Wells sunk in same. By H. W. Pearson, M.I.C.E. 327

Observations on British Mice. By H. Percy Leonard. . . 342

Hypnotism. By Francis H. Edgeworth, M.B., B.Sc., B.A. . 359

Language and Race. By Arthur B. Prowse, M.D., F.R.C.S. . 390

Cassava. By William Duncan, L.R.C.P. 418

Reports of Meetings, General and Sectional. 421

Index to Bristol Fungi. By Cedric Bucknall, Mus.Bac. . . 425

Index to Plates of Fungi 472

Title-page and Index to Vol. VI. of the Proceedings, 1888–91.

Presidential Address.

BY PROF. C. LLOYD MORGAN.

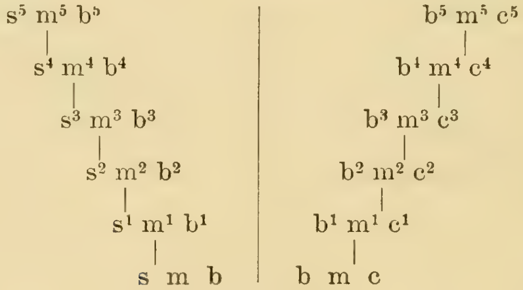
THE NATURE AND ORIGIN OF VARIATIONS.

NATURAL selection is dependent upon (1) the law of increase, or the tendency of every known species to increase in numbers ; (2) the struggle for existence, by which the tendency to increase is held in check ; and (3) the occurrence of variations. In the absence of variation those individuals which succumb in the struggle for existence would be similar to those which survive. The numbers would indeed be reduced, and the tendency to increase would be held in check ; but the species would remain unchanged. Given, however, the occurrence of variations in the offspring, the struggle for existence will act differentially. Those which fall below the standard of mediocrity will be eliminated, those which reach this standard or excel it will survive to procreate their kind. We may express this roughly and diagrammatically thus :—

$$\begin{array}{cccccccccccccl}
&&&&&&&&&&&& a^6 & \\
&&&&&&&&&& a^5 & — & m^6 & \text{etc.} \\
&&&&&&&& a^4 & — & m^5 & & b^6 & \\
&&&&&& a^3 & — & m^4 & & b^5 &&& \\
&&&& a^2 & — & m^3 & & b^4 &&&&& \\
&& a^1 & — & m^2 & & b^3 &&&&&&& \\
a & — & m^1 & & b^2 &&&&&&&&& \\
m & & b^1 &&&&&&&&&&& \\
b &&&&&&&&&&&&&
\end{array}$$

The letters *m*, *m*^{1}, etc., stand for the mean or average of the individuals born: a, a^1, etc., represent the individuals above the average: b, b^1, etc., represent the individuals below the average. The individuals represented by b, b^1, etc., are eliminated through the struggle for existence in each generation. There survive in each generation a, a^1, etc., and m, m^1, etc.; and these interbreed. Take, for example, the first group a, m, b: b are eliminated: a and m survive and intercross. Their offspring are again arranged as a^1, m^1, and b^1. But m^1 stands at a higher level than m, having been raised by the intermixture of m and a. Similarly of succeeding generations. The average of the species at m^2, m^3, m^4, m^5, and so on, is step by step raised through the action of natural selection. Such a progressive improvement of the species has been termed monotypic evolution. So far there is no divergence.

Divergence involves the segregation or isolation of the diverging groups. The segregation may depend on geographical, physiological, psychological, or other conditions; but there must be some means by which intercrossing and the interblending of the divergent characters are prevented. We may represent this roughly and diagrammatically thus:—



Here the divergence of a strong variety (s, s^1, etc.) from a cunning variety (c, c^1, etc.) is represented. Mediocrity is again indicated by m, m^1, etc., and the individuals below the average in these respects by b, b^1, etc. These are eliminated. The vertical line represents the bar to intercrossing which permits divergence. Do away with that bar and the divergence ceases. The individuals on either side of it interbreed, their characters will be blended, and there will be monotypic evolution. The race will perhaps increase in combined strength and cunning; but there will be no divergence into two races, the one strong and the other cunning.

Thus to render possible either transmutation or divergence, under natural selection through elimination, variation is essential. For Darwinism variation is a *sine quâ non.* But Darwinism, as such, is not bound to account for the origin of variations. It is sufficient that they occur.

Evidence of their occurrence is rightly demanded by the student of bionomics. And in answer to this demand Mr. A. R. Wallace has collected a large body of evidence in the chapter on "The Variability of Species in a State of Nature" in his *Darwinism.* So successful has he been in showing that variations in size "usually reaching 10 or 20, and sometimes even 25 per cent. of the varying part," and occurring in 5 to 10 per cent. of the specimens examined, do occur under nature, that one's faith is, perhaps, a little shaken in the inexorable efficiency of the struggle for existence as an eliminating agency. In any case it emphasizes a fact on which I have elsewhere endeavoured to lay stress, that a variation must reach a certain amount, and be of a fatally deleterious character, before it becomes of elimination value. We have been apt to suppose that a species is so nicely adjusted to its surrounding conditions that all variations from the type, unless of a very insignificant character, would be rapidly and inevitably weeded out. This, it is clear, is not true at any rate for some species.

At all events, however, the occurrence of variations is abundantly proved. Next as to the nature of the variations. Mr. Wallace says that the "variability extends, so far as we know, to every part and organ, whether external or internal." But I do not think the evidence brought forward justifies either the assertion or the denial that all possible variations occur—possible, that is to say, within the limits of the organization of the species. It may be so. But it may be that the variations occur in a number of definite and determinate lines. If this be denied,—if it be said that the evidence shows that variations of all kinds occur in equal proportions,—the opponent of Darwinism will perhaps be tempted to answer: What then is your Natural Selection doing? If variations of all kinds, within the limits you assign, are there in equal proportions, the presumption is that no varieties have been eliminated, and that natural selection, so far as these species are concerned, is inoperative. And the candid biologist must, I think, admit that the evidence in Mr. Wallace's chapter—I refer, of course, to the chapter on the variability of species under nature, not to the work as a whole—while conclusive as to the occurrence of variations, gives on analysis little or no evidence of any selective agency at work. I do not regard this absence of evidence as damaging to the Darwinian position. It is due to the incompleteness of the evidence—an incompleteness which also precludes our saying whether the variations are indefinite or along certain determined lines.

Evidence on this head is indeed particularly hard to obtain. If we look to established varieties and species, and, noting their determinate characteristics, are tempted to regard this as evidence of determinate variations, we are met at once by the Darwinian assertion that these characteristics are determinate through selection from among all other possible variations—variations which were not only possible, but which actually occurred, only elimination swept them away.

Does the evidence afforded by fossil remains help us here? Those American zoologists who have studied the evolution of mammalian teeth contend that the occurrence of new points and cusps is not indeterminate but determinate. New elements of tooth-structure appear in definite positions. There is nothing to indicate selection from among indefinite variations. Other evidence of like implication is adduced by American evolutionists; but this of tooth-structure is put forward as the strongest case. I am inclined to think that the facts of palæontology, so far as they go, point in this direction. But I question whether they can be regarded as conclusive. In criticising the position stress may be laid on the imperfection of the geological record; and it may be urged that the number of individuals in our palæontological collections is not sufficient to constitute a truly representative sample. Furthermore, on the hypothesis of selection, the individuals possessed of teeth with points and cusps in other than these adaptive positions must have been weeded out in the early stages of life. In view of these objections the evidence cannot be said to be convincing, though in my opinion it affords some presumption in favour of determinate variation.

Some direct evidence in this matter might be obtained by a careful, extensive, and long-continued series of observations on fish, amphibians, and insects, by rearing and examining all the individuals hatched out from a considerable number of batches of ova. It would not be sufficient to examine merely the numerous progeny of a single individual, since they would be likely to present in excess particular inherited tendencies. But if such determinate variations were found in the progeny of a number of individuals, the presumption would be that there was a race tendency to these determinate variations. The investigation would be laborious, and perhaps in the end not altogether convincing. In all cases the variations must be restricted within the limits of the organization of the species; and what exactly these limits are it is not easy to determine.

The question is rendered more complex by the correlation of variations. That when an organ such as the beak increases or decreases in length, adjoining and related parts such as the tongue and the orifice of the nostrils tend to vary conformably, is a comparatively simple case of correlation. That if the legs of pigeons be feathered the two outer toes are partially connected by skin, involves a correlation less simple. That in several breeds of the pigeon the length of the beak and the size of the feet are correlated, and that young pigeons of all breeds, which, when mature, have white, yellow, silver-blue, or dun-coloured plumage, come out of the egg almost naked—in these and sundry other well-known cases the *nexus* of correlation is by no means obvious. The whole question of co-adaptation which has recently come to the fore in discussions on Weismannism, is one of great difficulty. The development of the long neck of the giraffe and the gigantic horns of the extinct Irish reindeer must have involved numerous admirably co-ordinated modifications of structure. These have been brought forward by Mr. Herbert Spencer as presumptive evidence in favour of the inherited effects of use and disuse. Mr. Platt Ball, in his recent work, in criticising this position, has stated that Mr. Spencer's arguments were "so poorly founded as to be rejected by a far greater authority [Darwin] on such subjects." But Darwin himself said: "Although natural selection would thus tend to give to the male elk its present structure, yet it is probable that the inherited effects of use, and of the mutual action of part on part, have been equally or more important;" and this can hardly be regarded as very emphatic rejection! Of course it is open to the thorough-going Darwinian to say that the result has been reached by the selection of now one, now another, and subsequently yet other sets of correlated variations or co-adaptations, not produced by, but chancing to coincide with, effective utility. It would seem, however, that the occurrence of such co-adaptive sets of variations might fairly be regarded as indicative of directed or determinate variation, however originating. And in general the facts of correlation and co-adaptation seem, so far as they go, to point to determinate variation.

Still it may fairly be urged that such determinate variation may itself be the outcome of a long course of natural selection. If the individuals in which an adaptive correlation *a h n t* occurred were thereby placed among the survivors, while the individuals in which the non-adaptive correlations *a c m s*, *a b q z*, etc., occurred were thereby placed on the elimination list, it is clear that there would be ingrained in the species a tendency for the correlation *a h n t* to occur. Thus in a horned animal size of antlers and strength of supporting structures would be correlated; these again with proper blood-vessels and nerves; and so on. And again, in the ancestor of the giraffe, a number of co-adapted correlations would already be established, and these would form a sufficient basis for variation in the direction of the special and peculiar co-adaptations in the giraffe itself. In other words, even if the determinateness of the variations in any species be established, it does not follow that this is not the result of long selection among variations primitively indeterminate.

Is there any evidence which will help us to decide whether correlated variations are in all cases the result of natural selection through elimination? When we consider the evidence which is afforded by domesticated animals, the impression left on the mind (at any rate in my own case) is that the variations from which selection has been made have been determinate, and that if the tendency in particular directions is the result of natural selection there is not much direct evidence of the fact. In many cases the new varieties have originated in "sports"—that is to say, in determinate and somewhat marked aberrations from the type. The races of domestic pigeons so fully considered by Darwin, and summarized by Mr. Wallace, have probably originated to a greater extent from particular "sports," the characters of which have been intensified by selective breeding, than by the slow accumulation of small deviations from the original type. Here it would seem that there lies open a profitable field for experimental observation, with the object of throwing light on the direction or directions of variation in particular cases, and the dimensions so to speak of the steps of variation. Are the steps small and uniform, or does nature stride and even leap sometimes, and if so to what extent? The way in which pigeons tumble back in reversion is most remarkable and perhaps instructive. Darwin crossed white fantails with black barbs, and obtained black, brown, or mottled mongrels. He crossed a barb with a spot, and obtained dusky and mottled mongrels. He then crossed the two sets of mongrels; and forth stepped the wild rock-pigeon (or its counterpart) with blue colour, barred and white-edged tail, and double-banded wings. In reversion there are very considerable jumps.

Darwin, as is well known, thought it probable that variability of every kind is directly or indirectly due to changed conditions of life. Are the effects of such changed conditions determinate or indeterminate? There can be no question that in many cases the changes are quite definite. Changed food or changed climate produce particular and almost startling alterations. Instance the case of the Texan *Saturnia*, which when fed in Switzerland on a new plant (*Juglans regia* instead of *J. nigra*) was so altered both in colour and form that it appeared to be a new species. Instance again the remarkable changes in brine-shrimps produced by changes in the salinity of the water. Few biologists will be likely to question the determinate effects of the action of the environment on the individual.

On the whole, having lately had occasion to review the evidence with regard to the nature of variations, I am drawn toward the following conclusions: (1) that correlated variations tend to occur in definite or determinate lines; (2) that under natural selection some of these determinate variations have presumably been eliminated; but (3) that there is no sufficient evidential justification of the assertion that the determinate lines of variation are solely the products of natural selection.

We come now to the question of origin.

Undoubtedly an important source of origin of the variations which occur in the higher animals and plants is parental commixture. When two parents each contribute something towards the formation of offspring, there are four logical possibilities: (1) Characters may be inherited exclusively from one parent or the other. If all the characters are inherited from one parent, the offspring will resemble that parent. If some characters are inherited exclusively from one parent, and other characters from the other parent, the offspring will present a new combination of the parental characteristics. (2) The characters of the parents may blend in the offspring, the characteristics of which will be the means or averages of the parental characteristics. (3) The characters of the parents may, so to speak, conspire, so that a strong characteristic in each parent may be yet stronger in the offspring, and a weak characteristic yet weaker. (4) The characters of the parents may combine, so that from the union of characteristics derived from the two parents a new and slightly different characteristic may be produced.

It is probable that all four methods occur in nature. Mr. Galton has pointed out that exclusive inheritance is the rule with such characters as the colour of the eyes. It is also exemplified in the Ancon breed of sheep. Blending is probably very common. Breeders of domestic animals seem to regard the fact that characters conspire and strengthen in the offspring as in some cases established. And the combination of characters to give rise to new developments must have taken place again and again, unless we are to look outside parental commixture for a source of origin; for otherwise no such new developments could have arisen.

It may be said that such new developments are of fortuitous or chance origin. The term is perhaps convenient for expressing a mode of origin of which we at present know absolutely nothing. But it clearly does not open up any field for discussion or for observation.

And if we say that determinate variations under the influence of environment or through parental commixture are due to laws of organization, the only practical value of such a suggestion will be that it may induce us to try and ascertain what these laws of organization are. If the phrase is less misleading for students and the general public than "fortuitous origin," in that it implies a causal *nexus*, it will be perhaps more misleading if it should lead to the suppositition that the causal *nexus* is in any sense adequately known. Still, for myself, I prefer it to the "fortuitous" phraseology. The analogy, and it is at best a distant one, is with "laws of crystallization." We know that under different conditions the same chemical substance will crystallize as either *calcite* or *aragonite*, another as either *hornblende* or *augite*, another as either *marcasite* or *iron pyrites*. It is part of the inherent nature of the substance in each case: we cannot at present say much more than that. Similarly determinate variations, under different environing conditions, or under special combinations of characters, may be the outcome of the inherent nature of the organism concerned. That is probably the utmost we can say at present. Of course those who wholly disbelieve in determinate variations will murmur "moonshine." Let them prove their case. Let them show that the apparently determinate variations are not really such, or if they are such that they result from selection from among indeterminate variations. And let them explain the origin of new characters. If they are successful, I shall be one of the first to congratulate them. I am not wedded to any opinion. All I contend for is freedom of discussion and further observation. In effect the question, so far as we have got at present, is between "determinate variation under laws of organization," and "indeterminate change under a law of inherent variation."

We now come to the vexed question of use-inheritance, a convenient term coined by Mr. Platt Ball to express the transmission from parent to offspring of characters not innate in, but acquired during the lifetime of, the parent.

In evidence of this transmission of the effects of use and disuse, Mr. Herbert Spencer has adduced the diminution of the jaws in civilized races of man, the diminished biting muscles in lap-dogs, the development of the æsthetic faculties in man, and inherited epilepsy in guinea-pigs; while Mr. Darwin cited the reduced wings of birds in Oceanic islands, the drooping ears and deteriorated instinct of domesticated animals, the diminished wing-power and enhanced leg-strength in domestic ducks, the short-sightedness of civilized folk, the large hands of labourers' children, and the thickened sole in infants and even embryos.

This evidence has lately been carefully considered and rigidly criticised by Mr. Platt Ball in a little work, entitled, *Are the Effects of Use and Disuse Inherited?* Mr. Ball's criticisms are by no means of uniform cogency, and are at times decidedly weak. But he has done well in emphasizing the extreme difficulty of excluding the effects of selection and elimination by breeders and under nature. In illustration of this we may take the following case. Sir J. Crighton Browne has shown that in the wild duck the brain is nearly twice as heavy in proportion to the body as it is in the comparatively imbecile domestic duck. At first sight this looks like evidence of inherited effects of disuse. But it may fairly be urged that, owing to its stupidity, this imbecile may be more readily kept in domestication. Imbecility has thus been a character steadily selected by breeders, and has carried with it a reduction of brains. This may perhaps sound a little far-fetched as a mode of accounting for a reduction of nearly fifty per cent., but it emphasizes the difficulty or impossibility of excluding artificial selection as a factor in the observed modifications of domestic animals. So, too, with regard to natural selection. When we are told by Mr. Ball that "natural selection would favour thickened soles for walking on, and might also promote an early development which would ensure their being ready in good time for actual use," we may be tempted to question whether a thicker or thinner sole to the foot is a character of elimination value, whether it would determine survival or elimination, and make all the difference between passing or being plucked in life's great competitive examination. But if Mr. Ball likes to maintain that every advantage, no matter how slight, is of elimination value, there, so far as he is concerned, is an end of the matter. It is, of course, open to any one to argue thus: Selection is all-pervading; the slightest advantage is selected; therefore all advantageous modifications have been effected through selection, and there is no necessity to imagine the existence of any other factor. Although logically correct, I regard such an attitude as biologically and scientifically false. Even if selection be rightly regarded as by far the most potent factor in evolution, this does not of itself justify "grave doubts of the alleged inheritance of the effects of use and disuse," but rather shows the difficulty of proving or disproving such use-inheritance by special examples. In Science we must not say: Here are the major factors; these practically do all the work. Never mind about minor factors, the major factors are quite strong enough without them. We must endeavour to study the minor factors, or test their existence by the careful elimination of the major factors.

It is, however, as a source of origin of variations that use-inheritance is operative if operative at all. Granted that the imbecile ducks have been steadily selected; granted that the thickened sole has been favoured by natural selection; the true question is whether a tendency to variations in the direction of thickened epidermis and in the direction of diminished brains has been generated or fostered by use and disuse. Or take the case of the shifted eyes of flat-fishes. The question is not whether, given sufficient time, natural selection could or could not reach these results through the elimination of those fishes in which this particular variation did not chance to occur; the question is whether use-inheritance has *increased the percentage of these particular variations.* And it is a question on which, as it seems to me, it is exceedingly hard to obtain satisfactory evidence one way or the other.

Those who are disposed to regard use-inheritance as a factor in evolution have generally laid stress on the fact that it is the effects of persistent use or disuse through a series of generations that are effectual in giving a permanent set to the species. I am surprised, therefore, that Mr. Ball should attempt to show that use-inheritance, if it existed, would be detrimental to the species. It is surely self-evident that use-inheritance as a source of origin of variations would be beneficial to the species. According to Mr. Ball, adaptation is the result of the selection of favourable variations; use-inheritance, if it occurs, would provide an increased percentage of these favourable variations, and not leave the matter to chance. Surely this would be a clear gain. This, however, is no valid argument for its occurrence, unless we are prepared to take the questionable ground sometimes occupied by extreme selectionists, and say, Variations of all kinds are constantly occurring; a variation in the direction of use-inheritance would be beneficial; natural selection fosters and develops beneficial variations; therefore natural selection has developed use-inheritance. Grant the possibility of use-inheritance and this reasoning may hold good; but the whole question at present is as to the actual occurrence of use-inheritance or not. What we really want is evidence which, through the elimination of disturbing factors, shall point definitely in one direction or the other.

We have seen that the American school of biologists contend that variations, for example in tooth-structure, are determinate and not indeterminate. They also contend that these variations are largely due to the inherited effects of use and disuse. They tell us that in a large percentage of cases the new elements of tooth-structure appear in regions of ancestral wear and abrasion. Granting the determinate variations, we may perhaps inquire whether the abrasion may not be due to the presence of incipient points rather than the development of points to increased abrasion. It is admitted that the new points do not always occur where there has been previous abrasion. Granting the determinate variations, therefore, it does not appear to be satisfactorily proved that they are due to the effects of inherited use and disuse. Seeing the nature of tooth-growth and development, one needs very cogent evidence of the production of new points or cusps at regions of marked ancestral abrasion. The development of certain elements of vertebrate limb-structure and concomitant dwindling of other elements may be adduced as more readily comprehensible effects of inherited use and disuse. But here we have not the same evidence of the determinate nature of the variations, and the theory of selection from among favourable indeterminate variations is not to the same extent, on the showing of the American school themselves, excluded. It seems, then, that where the evidence for determinate variations is strong, the theory of use-inheritance is difficult of acceptation, and where use-inheritance is more readily comprehensible there is less evidence that the variations are determinate. To carry conviction it must be shown (1) that the variations are determinate, and (2) that the determination is due to the inherited effects of use and disuse. And of this there is at present no adequate proof.

To account for the diminution of organs or structures no longer of use, apart from any inherited effects of disuse, Mr. Romanes has invoked the cessation of selection; and Mr.

Francis Galton has, in another connection, summarized the effects of this cessation of selection in the convenient phrase "Regression to Mediocrity." This is the Panmixia of Professor Weismann and his followers; but the phrase regression to mediocrity through cessation of selection appears to me preferable. It is clear that so long as any organ or structure is subject to natural selection through elimination, it is, if not actually undergoing improvement, kept at a high standard of efficiency through the elimination of all those individuals in which the organ in question falls below the required standard. But if, from change in the environment or other cause, the character in question ceases to be subject to selection, elimination no longer takes place, and the high standard will no longer be maintained. There will be reversion to mediocrity. The probable amount of this reversion is at present a matter under discussion. Unless the principle of atavism is called into play to an extravagant extent, it does not seem probable that the reversion would be large in amount. Five per cent. would appear to be a very liberal estimate. In any long-established character, such as wing-power in birds, brain development, the eyes of crustacea, no shortcomer in these respects would have been permitted by natural selection to transmit his shortcomings for hundreds of generations. All tendency to such shortcomings would, one would suppose, have been bred out of the race. If after this long process of selection there still remains a strong tendency to deterioration, this tendency demands an explanation, unless we call into play reversion to ancestors dimly ancestral. The matter, however, should not be left to the arbitration of *a priori* reasoning. Definite experiments should be instituted to determine by observation the amount of regression. If the tendency to deterioration be strong, it should be found that the mean value of the character in the individuals born is markedly inferior to the mean value of the character in the few individuals which would normally be selected for survival. It might be found that the inferior individuals are for some reason prepotent over superior individuals, so that when an inferior and a superior individual are mated, the offspring inherit the inferiority to a greater degree than the superiority. Carefully directed experiments in which the possible effects of disuse were carefully excluded might do much to put this matter upon a more satisfactory basis of observed fact.

It has often been pointed out that reversion to mediocrity places a serious obstacle in the way of the establishment of new varieties when such arise sporadically. It is of course clear that where the variation is merely quantitative, a matter of excess or deficiency, this obstacle will not occur. There will be a certain proportion of variations in excess of the mean, and a certain proportion in the direction of deficiency. The latter will be eliminated, the former selected. There is no difficulty here. But if the variety be a peculiar and special one, not liable to frequent occurrence, the chances against those which happen to possess it mating together would be numerous, and, on the principle of blended inheritance, the reversion to mediocrity would tend to obliterate the new character. On the principle of exclusive inheritance this would not be so; and if, as in the case of the Ancon breed of sheep, the variety preferred to mate together rather than to mate with the parent form, segregation would take place, and reversion to mediocrity would be barred. But without some mode of segregation the sporadic variety would stand but a poor chance.

Take in further illustration of this point the shifted eyes of flat-fish. In the absence of distinct and definite evidence of the fact, one may suppose that an asymmetrical disposition of the eyes, with accompanying asymmetry of the skull and adjoining parts, is a variation of not very frequent occurrence. Still less frequent must be the asymmetry in the particular direction required. The chances against individuals possessing these very infrequent favourable variations happening to mate together would be many to one. And I take it to be exceedingly questionable whether the non-possession of an incipient asymmetry would constitute a character of elimination value. In which case there would be no selection of the incipient asymmetrical variety.

It is possible, however, that asymmetry in a marked degree occurred as a sport like the Ancon ram; that this sport was subject to exclusive inheritance; and that in this way there arose a variety which, being in harmony with the conditions of life, throve and multiplied, and eventually ousted the parental stock. If species have frequently arisen in this way, we must give up the old adage *Natura nil facit per saltum*. And in this connection we must remember that Darwin regarded the occurrence of a sudden strong deviation from symmetry as highly improbable. He says: "Mr. Mivart remarks that a sudden spontaneous transformation in the position of the eyes is hardly conceivable, in which I quite agree with him." Mr. Darwin's own account is entirely based on the view that the acquired effects of "straining the lower eyes so as to look upwards" are inherited.

In considering the swamping effects of intercrossing, Darwin candidly states that, until he read the now celebrated article by Professor Fleeming Jenkin in the *North British Review*, he "did not appreciate how rarely single variations, whether slight or strongly marked, could be perpetuated." And he says further on: "It should not, however, be overlooked that certain rather strongly marked variations . . . frequently recur, owing to a similar organization being similarly acted on,—of which fact numerous instances could be given with our domestic productions. . . . There can also be little doubt that the tendency to vary in the same manner has often been so strong that all the individuals of the same species have been similarly modified without the aid of any form of selection" (*Origin of Species*, p. 72). Now in the case of our flat-fishes' eyes the similar modification of considerable numbers of individuals (which would seem to be a *sine quâ non* on the hypothesis of gradual transformation) may be either due to laws of organization or to the inherited effects of use. A twisted skull and asymmetry of eyes seems *a priori* unlikely as the outcome of any inherent organic tendency, even though it were, as is possible, correlated with the concomitant tendency to lie on the side.

The inherited effects of use and disease would in this, and a great number of other cases, conveniently account for a large number of individuals varying in exactly the required direction. But this in itself does not justify us in accepting this view of the matter, unless it can be conclusively shown that all other explanations are barred by their improbability. The consideration of this case, however, suggests a possible line of experimental observation. Would it not be possible, without in any way maiming or giving pain, to induce in domesticated animals or birds, by weighting or handicapping one side of the body, a lop-sided development? If this were continued through a series of generations, without any selection, it might then be seen whether there was any tendency for this lopsidedness to be inherited. High action in the horse can be induced by weighting the limbs. I am not aware whether this has been done for a series of generations, and whether there is any indication of such high action being inherited. By differential weighting, however, a differential action might be established, and any hereditary tendency would be the more readily observable. Preliminary experiments in this direction on rapidly breeding animals would probably soon lead to indications of the most convenient form of continuing the experiments and observations. In single-lop rabbits there is a decided twist or set to the skull. There is no distinct evidence, at present, whether this is due to correlated variation or to the inherited effects of the lop. It would be possible, I suppose, to induce a lop in other strains of rabbits, and perhaps in guinea-pigs, and that quite painlessly by artificially weighting the left ear. A number of the rabbits or guinea-pigs might be at the outset divided into two groups, which should be kept as far as possible under similar conditions, except that in one set the left ear of each individual was kept slightly weighted. After four or five generations, certain individuals of the weighted group should be set aside, unweighted from their birth, and observed; while observations and measurements of the skulls of some of them should be made and recorded, and carefully compared with those made on the skulls of individuals weighted from birth. If it should be found that at the end of twenty or thirty generations, though the effects on the individual were well marked, there was no evidence of any inherited effect, such negative evidence would be *pro tanto* of value, while positive evidence obtained in this way does not seem to be open to damaging criticism.

Satisfactory proof of the inherited effects of increased use by itself will, I imagine, be difficult to obtain under experimental conditions; observations on the effects of disuse, by itself, would be complicated by the panmixia question; but observations such as I suggest, directed towards the inheritance of differential use, would be less open to these objections, and to the criticism that the effects might be due to the conditions of domestication.

In any case, in my opinion, this question of use-inheritance will not be settled one way or the other without experimental evidence and definite observation. Neither side will be satisfied with *a priori* arguments.

And it is a question of wide bearing. In psychology, not only does it assume importance in all considerations concerning the origin of instincts, but it profoundly affects the arguments of the modern experiential school, which holds or has held that what is psychologically innate is largely due to inherited experience. If the growing disbelief in use-inheritance be justified on the ground of experimental observation, psychologists, not for the first time, will have to readjust their conclusions so as to harmonize with the teachings of biological science.

The social bearings of the question are also by no means unimportant. The advocates of fuller and freer education have for the most part believed that the improvement of one generation will in some degree be transmitted to the next. If use-inheritance be disproved, there is no such transmission. The average innate intellectual and moral capacity of the generation of Englishmen now being born cannot on this view be much higher, and is probably somewhat lower than it was some half-dozen generations ago. Commenting on this social aspect of the question, Professor Le Conte, in a recent paper (*Monist*, vol. i., no. 3), says:—"If it be true that reason must direct the course of human evolution, and if it be also true that selection of the fittest is the only method available for the purpose; then, if we are to have any race-improvement at all, the dreadful law of *destruction* *of the weak and helpless* must with Spartan firmness be carried out voluntarily and deliberately. Against such a course all that is best in us revolts. The use of the Lamarckian factors (use-inheritance), on the contrary, is not attended with any such revolting consequences. All that we call education, culture, training, is by the use of these. Our hopes of race-improvement, therefore, are strictly conditioned on the fact that the Lamarckian factors are still operative, that changes in the individual, if in useful direction, are to some extent inherited and accumulated in the race."

Now even if the outlook were as gloomy as Professor Le Conte believes it to be, this will not alter the stern facts of inheritance. To say, "The consequences of my view are so much more comforting than the consequences of your view, that my view must be true," can hardly be regarded as valid argument. Such pleading for use-inheritance is, however, presumably not addressed to the man of science as such, but to the philanthropist as such. But, without forejudging a case which is still, I contend, *sub judice*, I think that, supposing use-inheritance be disproved, the possibilities of race-improvement do not lie wholly in a ruthless and pitiless system of social elimination.

The race, like the individual, is moulded in relation to its environment. Now for the human race, as human, the environment is largely and increasingly a matter of ideas and ideals. I have not time to enter into this question, but I utterly disbelieve that natural selection is the main determining factor of human progress. Now, what we seek to do by the spread of intellectual training, and of that which is more important by far, moral training, is to let each succeeding generation grow up in closer and closer touch with an improved and improving environment of intellectual ideas and moral ideals. If each generation grows up in better harmony with a better social environment, it will be so far better than its predecessors. The race will be improved by the extension and improvement of the social environment. If in addition to this, the race, through inherited effects of this environment, starts in each generation at a slightly higher level, so much the better. But this is just the question at issue—a question which can only be decisively settled by reducing it to its simplest terms and applying it to the touchstone of experiment and observation.

In last week's *Nature* (vol. xliii., p. 581) Mr. Thistleton-Dyer writes: "I have met with one plant in which I thought that I had got a case of the transmission of an acquired habit. Mr. Churchill procured for us seeds of *Arabis anachoretica*, 'a form of *A. alpina*, L., with thin tissue-papery leaves, growing in hollows of the rock, where neither sun nor rain reach it, just as *Saxifraga arachnoidea*, as also *Heliospermum glutinosum*, and *Zahlbruchnera paradoxa*, all which have very thin tissue-papery leaves.' Alas, on cultivation at Kew it reverted forthwith to commonplace *Arabis alpina*." This is a good illustration of the influence of environment on the race. Had the seeds germinated in the rock-hollows beyond the reach of rain and sun, the leaves, it appears, would have been tissue-papery. But removed to a less abnormal environment they assume their ordinary form. Such a case does not necessarily disprove use-inheritance. But it shows the extreme plasticity of the individual, and it shows that the influence of the normal environment is prepotent over the effects of use-inheritance *if* such occur. It also seems to show a particular determinate effect of a peculiar abnormal environment, not only on this plant but on others. And since the effects of environment are thus seen to be potent and determinate, it leads us to look in other directions than experiments with changed environment for crucial observations with regard to use-inheritance.

In experiments to test the question of use-inheritance, the difficulty is to exclude the effects (1) of selection and (2) of individual plasticity. As to the first difficulty I have said enough. With regard to the second, all admit that the individual, especially in the early stages of life, is plastic and to some extent moulded by the environment under the influence of which it develops. To what extent is it plastic? And if the individual effect is in any degree hereditary, what percentage of the individual effect is handed on to the next generation? Those who maintain that the effects of the environment, or of individual use, must, if they are to become ingrained in the race, be long continued and persistent, hold, I presume, that only a small percentage of the individual effect is transmitted. If this be so, if the "hereditary effect" is but a small percentage of the "individual effect," it will require great care to insure that the small "hereditary effect" (if such there be) is not lost sight of from its being masked or hidden by the far larger "individual effect." The subject is full of difficulties, logical and biological, and we must be careful not to slur them over.

In conclusion, I am anxious that the attitude I assume and advocate in this matter of use-inheritance should not be misunderstood. We hear both on the one side and on the other somewhat dogmatic utterances. We are told on the one hand that natural selection has no need of the assistance of a Lamarckian factor of the effects of which there is no shadow of proof, and the *modus operandi* of which is an inscrutable mystery. We are told on the other hand that natural selection is tottering to its fall. I advocate an anti-dogmatic attitude. I desire to see the matter fairly and temperately discussed, as Darwin would have discussed it (with a breadth and sweep of view how difficult of attainment!); and, above all, I desire to see it submitted to the touchstone of patient, well-planned, rigorous, and decisive experimental observation. Whatever the answer may be to this particular question, I am convinced that the nature and origin of variations on which I have ventured to address you to-night is a question which will occupy an increasing share of attention on the part of evolutionists in the near future.

The Fungi of the Bristol District.

PART XIII.

By CEDRIC BUCKNALL, Mus.Bac.

THE following species are either new, or have occurred for the first time in Britain:—

1401. AGARICUS (COLLYBIA) EUSTYGIUS, *Cooke, Illus. Supp. t. 1185.*

1404. CORTINARIUS (PHLEGMACIUM) TESTACEUS, *Cooke, Illus. Supp. t. 1190.*

1419. OLIGONEMA FURCATUM, *Bucknall, n. sp.*

1429. HELOTIUM DEPARCULUM, *Karst. Myc. Fenn., p. 150.*

1430. LACHNELLA GLOBULIFERA, *Fckl.*

1431. LACHNELLA FRAGARIASTRI, *Phillips in litt.*

1400. Agaricus (Tricholoma) imbricatus, *Fr.*	Abbot's Leigh, Sept., 1890.
1401. Agaricus (Collybia) eustygius, *Cooke, Illus. Supp. t. 1185.*	Leigh Woods, Sept., 1880.

"Pileus rather fleshy, convex, then plane, sometimes depressed (3–5 c.m. broad), even, smooth, becoming shining when dry, tough, dingy white, a little darker about the disc, margin thin, smooth, occasionally flexuous; stem stuffed, rarely hollow, attenuated downwards into a rooting base (5–8 c.m. long, 6–8 m.m. thick), white above, sprinkled with small punctate scales, darker below, and often becoming fuliginous, somewhat longitudinally striate or fibrous; gills rather broad, rounded behind, not crowded, dark grey. Spores white, globose, 4–5 μ. Odour of rancid meal. Whole plant in drying becoming black." *Cooke in Grevillea, vol. xix., p. 40.*

One specimen of this well-marked *Collybia* was found in the Leigh

Woods in the year 1880, and it had not been noticed since that time, until 1890, when several specimens were met with at an excursion of the Woolhope Club to Whitfield, near Hereford. The upper figure in *Cooke, Illus. t. 1185*, is taken from a drawing of the Leigh Wood specimen, the others from those from Whitfield.

1402.	Agaricus (Pluteus) ephebius, *Fr.*	Leigh Woods,	Sept., 1890.
	*Agaricus (Inocybe) asterospora, *Quel.*	Sandy Lane,	Aug., 1877.
1403.	Agaricus (Stropharia) merdarius, *Fr.*	Abbot's Leigh,	Aug., 1890.
1404.	Cortinarius (Phlegmacium) testaceus, *Cooke, Illus. Supp. t. 1190.*	Westridge Wood,	Sept., 1881.

"Pileus fleshy, convex, then flattened and obtusely umbonate, or depressed (7–10 c.m. broad), brick-red, rather vinous, growing paler with age, smooth, even, viscid; stem (8–9 c.m. long, 1½ c.m. thick) attenuated upwards, from a sub-marginate, bulbous base, whitish above, becoming rufous about the base, solid, longitudinally fibrously striate below; flesh rather flesh-coloured, becoming ruddy at apex and base; gills broad (1 c.m.), scarcely crowded, adnate, a little emarginate behind, dusky cinnamon; spores elliptic, narrowed at each end, rough, 16×8 μ." *Cooke, Revis. Hd.-bk. Brit. Fungi, p.* 378.

This species, like *A. eustygius*, was met with in this district some years ago, in 1881, and is recorded at No. 860, vol. III., p. 264, as *Cort. russus.* It was also found at the Fungus Foray at Whitfield, a few hundred yards from where *A. eustygius* grew, and, being found to differ entirely from *Cort. russus*, was described as new by Dr. Cooke. The larger figure in the "Illustrations" is taken from a drawing of the Westridge Wood specimen.

	*Cortinarius (Phlegmacium) purpurascens, *Fr.*	Brockley Coombe,	Oct., 1890.
1405.	Cortinarius (Inoloma) violaceus, *Fr.*	Leigh Woods,	Sept., 1890.
1406.	Cortinarius (Dermocybe) orellanus, *Fr.*	Leigh Woods,	Sept., 1890.
1407.	Cortinarius (Telamonia) rigidus, *Scop.*	Leigh Woods,	Nov., 1890.
1408.	Lactarius trivialis, *Fr.*	Brockley Coombe,	Oct., 1890.

	* Lactarius fuliginosus, *Fr.* Recorded in Vol. II., p. 212, as *L. acris.*	Haw Wood,	Aug., 1877.
1409.	Russula cærulea, *Pers.* *Cooke, Illus. t. 1052.*	Coombe Hill,	Oct., 1890.
1410.	Russula rubra, *var.* sapida, *Cooke, Illus. t. 1087.*	Leigh Woods,	Sept., 1890.
1411.	Russula granulosa, *Cooke,* *Illus. t. 1038.*	Abbot's Leigh,	Sept., 1890.
1412.	Russula puellaris, *Fr.* *Cooke, Illus. t. 1065.*	Leigh Woods,	Nov., 1890.
1413.	Marasmius erythropus, *Fr.*	Portishead,	Sept., 1890.
1414.	Boletus tenuipes, *Cooke.*	Leigh Woods,	Sept., 1890.
1415.	Polyporus picipes, *Fr.*	Abbot's Leigh,	Sept., 1890.
1416.	Craterellus crispus, *Fr.*	Leigh Woods,	Oct., 1890.
1417.	Peniophora velutina, *Cooke.*	Leigh Woods,	July, 1890.
1418.	Cyphella rubi, *Fckl.*	Clevedon,	July, 1890.
1419.	Oligonema furcatum, *Bucknall, n. sp.*	Abbot's Leigh,	Nov., 1890.

Sporangia scattered, globose, *shining*, *bright chrome yellow* as well as the capillitium and spores; elaters cylindrical, simple or branched, slightly thickened at the obtuse ends, with a faint open spiral, 3-4 μ diameter; spores globose, *minutely warted*, 11–12 μ diameter.

Superficially, closely resembling *Oligonema nitens*, from which, however, it is quite distinct in the minutely warted spores, and the absence of thickened rings in the usually furcate elaters.

On a rotten trunk.

1420.	Perichæna confusa, *Massee in litt.,* *Ellis, N. Amer. Fungi, No. 726* *(as Ophiotheca umbrina, Berk.).* *Perichœna variabilis, Rost.* *Physarum vermiculare, Sz.*	Yatton,	Jan., 1890.

Sporangia hemispherical and scattered or æthalioid and often forming an irregular network, pale umber or dingy ochraceous, dehiscing irregularly; capillitium well developed, forming an irregular loose network, threads 2–4 μ thick, irregularly notched; spores subglobose, 13–14 μ diameter, smooth; mass of capillitium and spores dingy ochraceous, sometimes with a suggestion of olive.

1421. Puccinia menthæ, *Pers.* Uredo and teleutospores.	West Harptree,	Sept., 1890.
1422. Puccinia pruni, *Pers.* Uredospores.	Clevedon,	Sept., 1890.
1423. Puccinia coronata, *Corda.* Æcidiospores. *Æcidium crassum.*	Tickenham Hill,	June, 1891.
On *Rhamnus catharticus.*		
1424. Ustilago tragopogi, *Pers.* *U. receptaculorum, Fr.*	Clevedon,	Sept., 1890.
1425. Æcidium punctatum, *Pers.* *Æ. quadrifidum, D.C.*	Clevedon,	May, 1891.
1426. Volutella ciliata, *Fr.*	Clevedon,	July, 1890.
1427. Peziza polytrichi, *Schum.*	The Gully,	May, 1891.
1428. Morchella esculenta, *Linn.*	Brentry,	May, 1879.
1429. Helotium deparculum, *Karst. Myc. Fenn. p. 150, Pseudhelotium deparculum, Sacc.*	Ashton,	July, 1885.

Gregarious, at first spheroid, then nearly plane, when dry hemispherical and concave, sessile, furfuraceo-puberulous, pallid or pallid yellow, when dry ochraceous or reddish-yellow, ·03–·04 m.m. broad; asci cylindraceo-clavate, 4-spored, 30–45 $\mu \times$ 4–5 μ; spores linear-fusoid, straight or curved, simple or pseudo-septate, 12–15 $\mu \times$ 1·5 μ; paraphyses few, slender.

On dead stems of *Spiræa ulmaria.*

1430. Lachnella globulifera, *Fckl.*	Clevedon,	
1431. Lachnella fragariastri, *Phillips, n. sp. in litt.*	Clevedon, Mr. R. Baker,	June, 1890.

Gregarious; stipitate, firm, cyathiform, faint purplish-red, paler near the margin, clothed with short, hyaline simple hairs, usually enlarged at the summit; asci subclavate; sporidia 8, fusiform or oblongo-fusiform, 5 × 1–2 μ; paraphyses acerose, rather stout, somewhat abruptly acuminate.

On dead or dying strawberry stems.

Phenological Records for 1890.

PLANTS.

Recorders: Miss ANNIE BAKER, Bridgwater (A.B.); Mr. DAVID FRY, Corston (D.F.); Mr. H. S. B. GOLDSMITH, Bridgwater (H.S.B.G.); Mr. LEWIS W. ROGERS, Clifton (L.W.R.); Mr. H. STUART THOMPSON, Bridgwater (H.S.T.).

Abbreviations.—App., first appearance above ground; Bud. b., first buds bursting; Fol., almost in full foliage; Fl., first flower; R. fr., first ripe fruit.

1. *Anemone nemorosa* (*Wood Anemone*).—Fl. March 20th, near Bridgwater, H.S.T.; March 20th, Combe Dingle, L.W.R.; March 27th, Stantonbury Hill, D.F.; March 29th, Durleigh, near Bridgwater, H.S.B.G.

2. *Ranunculus ficaria* (*Pilewort, Lesser Celandine*).—Fl. March 7th, Combe Dingle, L.W.R.; March 14th, Corston, D.F.

3. *Ranunculus acris* (*Upright Crowfoot*).—App. April 15th, Long Ashton, L.W.R.; Fl. April 24th, Hamp, A.B.; May 3rd, Ham Green, L.W.R.; May 9th, Corston, D.F.

4. *Caltha palustris* (*Marsh Marigold*).—Fl. March 14th, Cannington, near Bridgwater, H.S.B.G.; March 20th, near Bridgwater, H.S.T.; April 1st, Corston, D.F.; April 5th, Markham Bottom, L.W.R.

5. *Papaver rhœas* (*Red Poppy*).—Fl. June 12th, Corston, D.F.; June 20th, Hamp, A.B.

6. *Nasturtium officinale* (*Watercress*).—Fl. May 19th, Hamp, A.B.; May 26th, in quantity, Kilve, near Bridgwater, H.S.B.G.; June 2nd, near Compton Dando, D.F.

7. *Cardamine pratensis* (*Cuckoo Flower*).—Fl. April 3rd, Stantonbury Hill, D.F.; April 5th, Markham Bottom, L.W.R.

8. *Alliaria officinalis* (*Jack by the Hedge*).—App. Jan. 7th, the Gully, Durdham Down, L.W.R.; Fl. March 8th, near Bridgwater, H.S.B.G.; April 8th, Corston, D.F.

9. *Draba verna* (*Whitlow Grass*).—App. Jan. 7th, Gully, Durdham

Down, L.W.R.; Fl. March 10th, same locality, L.W.R.; March 27th, near Street, H.S.T.; R. fr. April 3rd, Corston, D.F.

10. *Viola odorata* (*Sweet Violet*).—Fl. March 14th, Corston (purple-flowered variety), D.F.

11. *Polygala vulgaris* (*Milkwort*).—Fl. May 24th, Cannington, A.B.; June 3rd, near Pensford, D.F.

12. *Lychnis diurna* (*Red Campion*).—Fl. May 1st, Hamp, A.B.; May 3rd, Corston, D.F.; May 4th, Dodington, near Bridgwater, H.S.B.G.

13. *Stellaria holostea* (*Greater Stitchwort*).—Fl. April 2nd, Hamp, A.B.; April 9th, near Compton Dando, D.F.; April 9th, Frome Glen, L.W.R.

14. *Cerastium pumilum* (*Mouse ear*).—Fl. April 6th, Gully, Durdham Down, L.W.R.

15. *Malva sylvestris* (*Common Mallow*).—Fl. May 30th, Stawell A.B.; June 12th, Corston, D.F.

17. *Hypericum perforatum* (*Perforate St. John's Wort*).—Fl. July 8th, Durleigh, A.B.; July 18th, Clevedon, D.F.

18. *Hypericum pulchrum* (*Upright St. John's Wort*).—Fl. July 4th, Keynsham, D.F.

19. *Geranium Robertianum* (*Herb Robert*).—Fl. May 4th, Dodington, H.S.B.G.; May 7th, Hamp, A.B.; May 11th, Corston, D.F.

20. *Euonymus europæus* (*Spindle tree*).—Bud. b. March 14th, Corston, D.F.; Fol. May 4th, Corston, D.F.; Fl. May 24th, Corston, D.F.; May 27th, Durleigh, A.B.

21. *Acer pseudo-platanus* (*Sycamore*).—Fol. April 28th, Corston, D.F.; April 28th, Bridgwater, H.S.B.G.; Fl. same date and place, H.S.B.G.

22. *Æsculus hippocastanum* (*Horse Chestnut*).—Bud. b. March 26th, Bridgwater, H.S.T.; April 7th, Newton St. Loe, D.F.; Fol. April 27th, same locality, D.F.; Fl. May 1st, Newton St. Loe, D.F.; May 4th, Bridgwater, H.S.B.G.; May 5th, Hamp, A.B.

23. *Cytisus laburnum* (*Laburnum*).—Bud. b. Corston, D.F.; Fl. May 12th, Corston, D.F.

24. *Trifolium repens* (*Dutch or White Clover*).—Fl. June 4th, Corston, D.F.

25 *Lotus corniculatus* (*Bird's-foot Trefoil*).—Fl. May 4th, Dodington, H.S.B.G.; June 3rd, Corston, D.F.

26. *Vicia cracca* (*Tufted Vetch*).—Fl. July 11th, near Compton Dando, D.F.

27. *Vicia sepium* (*Bush Vetch*).—Fl. April 26th, Sea Mills, L.W.R.; April 28th, Newton St. Loe, D.F.; R. fr. July 4th, Keynsham, D.F.

28. *Lathyrus pratensis* (*Meadow Vetchling*).—Fl. June 2nd, Durleigh, A.B.; June 25th, near Queen Charlton, D.F.

29. *Prunus spinosa* (*Sloe or Blackthorn*).—Bud. b. March 27th,

Bridgwater, H.S.T.; April 16th, Corston, D.F.; Fol. May 4th, Corston, D.F.; Fl. March 29th, Corston, D.F.; April 4th, near Durleigh, A.B.; April 5th, Durdham Down, L.W.R.

30. *Spiræa ulmaria* (*Meadow-sweet*).—Fl. June 9th, Durleigh, A.B.; June 27th, Keynsham, D.F.

31. *Potentilla anserina* (*Silver-weed*).—App. April 9th, Frome Glen, L.W.R.; Fl. May 20th, Hamp, A.B.; May 31st, Burnham, H.S.B.G.

32. *Rosa canina* (*Dog Rose*).—Bud. b. March 17th, Corston, D.F.; March 20th, Bridgwater, H.S.T.; Fol. April 23rd, Corston, D.F.; Fl. May 26th, Hamp, A.B.; June 3rd, Corston, D.F.

33. *Pyrus aucuparia* (*Mountain Ash or Rowan*).—Fl. May 7th, Locksley Wood, in full bloom, A.B.

34. *Pyrus aria* (*White-beam*).—Fol. May 1st, Leigh Woods, L.W.R.

35. *Cratægus oxyacantha* (*Hawthorn*).—Bud. b. March 22nd, Corston, D.F.; March 27th, Bridgwater, H.S.T.; Fol. April 6th, Durdham Down, L.W.R.; April 26th, King Square, Bridgwater, H.S.B.G.; April 27th, Corston, D.F.; Fl. April 26th, King Square, Bridgwater, H.S.B.G.; May 11th, Hamp fields, A.B.; May 15th, Corston, D.F.; R. fr. Aug. 19th, Hamp fields, A.B.

36. *Epilobium hirsutum* (*Great Hairy Willow Herb*).—App. April 9th, Frome Glen, L.W.R.; Fl. July 9th, Rhode Lane, A.B.; July 14th, Corston, D.F.

37. *Epilobium montanum* (*Broad Willow Herb*).—Fl. June 11th, Corston, D.F.; R. fr. July 16th, Corston, D.F.

38. *Angelica sylvestris* (*Wild Angelica*).—Fl. Aug. 16th, Houndstreet, D.F.

39. *Daucus carota* (*Wild Carrot*).—Fl. July 18th, Clevedon, D.F.

41. *Cornus sanguinea* (*Dog Wood*).—Fol. May 15th, Corston, D.F.; Fl. June 9th, Hamp, A.B.; June 13th, Corston, D.F.

42. *Adoxa Moschatellina* (*Moschatel*). — App. March 7th, Combe Dingle, in foliage, L.W.R.; Fl. March 18th, same locality, L.W.R.; March 20th, Bridgwater, H.S.T.; April 1st, Corston, D.F.

43. *Syringa vulgaris* (*Lilac*).—Bud. b. March 15th, Corston, D.F.; Fol. April 28th, Corston, D.F.; Fl. April 26th, Bridgwater, in the Square, H.S.B.G.; April 28th, St. Mary St., Bridgwater, A.B.; May 8th, Corston, D.F.

44. *Galium aparine* (*Cleavers*).—Fl. May 8th, Hamp, A.B.; May 21st, Corston, D.F.

45. *Galium verum* (*Yellow Bedstraw*).—Fl. June 25th, Queen Charlton, D.F.

46. *Dipsacus sylvestris* (*Wild Teasel*).—App. May 3rd, opposite Sea Mills, L.W.R.; Fl. July 28th, Corston, D.F.

47. *Scabiosa succisa* (*Devil's bit*).—Fl. August 16th, near Marksbury, D.F.

48. *Petasites vulgaris* (*Butterbur*).—Fl. March 15th, Corston, not fully in flower, though many of the florets were perfectly expanded, and must have been open some days before that date, D.F.

49. *Petasites fragrans.*—Fl. Dec. 20th, 1889, Bank of Avon, L.W.R.; Jan. 10th, Bridgwater, H.S.T.; Fol. February, L.W.R.

50. *Tussilago farfara* (*Coltsfoot*).—Fl. Feb. 10th, Corston, D.F.; March 8th, near Bridgwater, H.S.B.G.; March 10th, Clifton, L.W.R.

51. *Achillea millefolium* (*Yarrow*).—Fl. June 25th, Pensford, only a few florets expanded, probably in full flower a day or two later, D.F.; July 1st, Hamp fields, A.B.

52. *Chrysanthemum leucanthemum* (*Ox-eye*).—Fl. May 30th, near Corston, D.F.

53. *Artemisia vulgaris* (*Mugwort*).—Fl. August 4th, near Compton Dando, D.F.

54. *Senecio Jacobæa* (*Ragwort*).—Fl. June 12th, by canal, Bridgwater, A.B.; July 18th, Clevedon, D.F.

55. *Centaurea nigra.*—Fl. June 16th, near Compton Dando, D.F.

56. *Carduus lanceolatus* (*Spear Thistle*).—Fl. July 11th, near Compton Dando, D.F.

57. *Carduus arvensis* (*Field Thistle*).—Fl. July 11th, near Compton Dando, D.F.

59. *Hieracium pilosella* (*Mouse-ear Hawk-weed*).—Fl. May 31st, Saltford, D.F.; May 31st, Burnham, H.S.B.G.

60. *Campanula rotundifolia* (*Hair-bell*).—Fl. July 1st, St. Mary Street, Bridgwater, A.B.; July 29th, near Bath, D.F.

61. *Ligustrum vulgare* (*Privet*).—Fl. June 9th, near Durleigh, A.B.; June 16th, Corston, D.F.

62. *Convolvulus sepium* (*Greater Bindweed*).—Fl. July 5th, Corston, D.F.

63. *Symphytum officinale* (*Comfrey*).—Fl. April 27th, Corston, D.F.; May 16th, Hamp, A.B.

64. *Pedicularis sylvatica* (*Red Rattle*).—Fl. April 30th, Pill, L.W.R.

65. *Veronica chamædrys* (*Germander Speedwell*).—Fl. April 25th, Corston, D.F.; April 26th, Sea Mills, L.W.R.

66. *Mentha aquatica* (*Watermint*).—Fl. Aug. 16th, Houndstreet, D.F.

68. *Prunella vulgaris* (*Self-heal*).—Fl. May 26th, near Wembdon, A.B.; June 12th, Corston, D.F.

69. *Nepeta glechoma* (*Ground Ivy*).—Fl. March 14th, Corston, D.F.

70. *Lamium galeobdolon* (*Archangel*).—Fl. April 9th, Frome Glen, L.W.R.; May 14th, Kelston, D.F.

71. *Stachys sylvatica* (*Hedge Woundwort*).—Fl. May 25th, Hamp, A.B.; June 12th, Corston, D.F.

73. *Primula veris* (*Cowslip*).—Fl. March 27th, near Street, H.S.T.; April 8th, Sea Mills, L.W.R.; April 9th, near Compton Dando, D.F.

74. *Plantago lanceolata* (*Ribwort Plantain*).—Fl. April 21st, Hamp, A.B.; May 17th, Corston, D.F.

75. *Mercurialis perennis* (*Dog's Mercury*).—Fl. March 18th, Clifton Down, L.W.R.; April 3rd, Stantonbury Hill, some flowers with ripe pollen; April 9th, mature stigmas, D.F.

77. *Salix caprea* (*Great Sallow*).—Fl. March 15th, riverside, female fully developed, male somewhat later, L.W.R.; March 16th, Bridgwater, probably in flower a fortnight earlier, H.S.T.

78. *Fagus sylvatica* (*Beech*).—Bud. b. May 4th, Corston, D.F.; Fol. May 10th, Corston, D.F.

79. *Corylus avellana* (*Hazel*).—Bud. b. April 2nd, Corston, D.F.; Fol. May 17th, Corston, D.F.; Fl. March 14th, Corston, D.F.; in few catkins the pollen was ripe and few stigmas mature.

80. *Orchis maculata* (*Spotted Orchis*).—Fl. May 4th, Dodington H.S.B.G.; June 3rd, near Pensford, D.F.

81. *Iris pseud-acorus* (*Yellow Iris*).—Fl. May 26th, Petherton Levels, A.B.; June 16th, near Compton Dando, D.F.

82. *Narcissus pseudo-narcissus* (*Daffodil*).—Fl. April 4th, Failand, L.W.R.

84. *Scilla nutans* (*Blue-bell*).—Fl. April 13th, Goathurst, near Bridgwater, H.S.B.G.; April 18th, between Durleigh and Wembdon, A.B.; April 23rd, Corston, D.F.; April 25th, Markham Bottom, L.W.R.

BIRDS.

Recorders: Miss Annabella Alleyne, Leigh Woods (A.A.); Mr. H. S. B. Goldsmith, Bridgwater (H.S.B.G.).

2. *Muscicapa grisola* (*Fly-catcher*).—First seen May 18th, Rownham House, A.A. Seen May 27th, Bridgwater, date of arrival not known; young flying July 10th; date of leaving not known, none seen Sept. 20th, H.S.B.G.

3. *Turdus musicus* (*Song Thrush*).—Song, January; young flying May 3rd, in garden, A.A. Young nearly fledged on April 21st, H.S.B.G.

4. *Turdus pilaris* (*Fieldfare*).—First seen Oct. 24th, Dodington, H.S.B.G.

6. *Daulias luscinia* (*Nightingale*).—Song, May 3rd, Shirehampton, A.A. Seen and heard singing May 1st, Wembdon, near Bridgwater, H.S.B.G.

7. *Saxicola œnanthe* (*Wheatear*).—September 18th, about twenty seen on the Downs, A.A.

9. *Phylloscopus trochilus* (*Willow Wren*).—First seen and heard singing April 22nd, Leigh Woods, near top of Nightingale Valley, A.A. First seen March 30th, at Durleigh, near Bridgwater, among the bushes overhanging Durleigh stream, only one seen; song May 2nd, same locality; May 12th, Enmore, near Bridgwater, five eggs fresh, H.S.B.G.

10. *Phylloscopus collybita* (*Chiffchaff*).—First seen April 20th, at Leigh Woods, top of Nightingale Valley; song April 22nd, A.A. Song April 1st, Puriton, near Bridgwater, two heard about 5.30 p.m.; heard also at Dodington, near Bridgwater (autumn note), Sept. 15th–20th; nest, May 3rd, Kilve, near Bridgwater; eggs May 20th, in the same locality, five in number (many nests found during May and June), H.S.B.G.

12. *Emberiza schœniclus* (*Reed Bunting*).—May 24th, near Taunton, saw old birds going with food to nest, but not able to see young, nest among some rushes in a swamp; June 1st, near Bridgwater, nest with five eggs, slightly incubated, H.S.B.G.

14. *Emberiza cirlus* (*Cirl Bunting*).—Eggs, May 26th, at Kilve, Bridgwater, three in number, slightly incubated.

15. *Fringilla cœlebs* (*Chaffinch*).—We see them all the year round, but in winter very few cock-birds, A.A. Song, April 21st (not the "chink"), H.S.B.G.

18. *Cuculus canorus* (*Cuckoo*).—Song, April 24th, Leigh Woods, A.A. Seen and heard singing April 29th, Durleigh, near Bridgwater, two seen; also I heard the low churning note.

19. *Hirundo rustica* (*Swallow or Chimney Swallow*).—First seen April 15th, flying round the house, A.A. April 14th, a few at Puriton, near Bridgwater, reported to have been seen a week earlier in the same place, only seen in any numbers on the 21st, and the first time in the town on the same day; nest with four eggs Aug. 19th, Stowey, near Bridgwater, hatched June 3rd, Dunwear, near Bridgwater. Main body of birds gone October 1st, late brood left North Petherton, the last place of their stay near here, Oct. 12th. Young of first brood feeding young of second, see my letter in *Zoologist*, H.S.B.G.

20. *Hirundo urbica* (*House Martin*).—First seen May 17th, Leigh Woods, round the house; very few seen here this year, A.A. Seen April 14th, a few at Puriton, near Bridgwater; reported to have been seen on March 29th, in the same place; the first was in the town on the 20th, and the main body on the 21st; last seen Sept. 24th. H.S.B.G.

21. *Hirundo riparia* (*Sand Martin*).—First seen April 14th, Puriton, near Bridgwater; reported to have been seen on March 19th, in the same place; none seen on my return to Bridgwater, Sept. 20th, H.S.B.G.

22. *Cypselus apus* (*Swift*).—Seen May 17th, round the house. Swifts unusually numerous, A.A. First seen May 7th, Bridgwater, a pair; last seen August 10th, Bridgwater, H.S.B.G.

23. *Caprimulgus europæus* (*Goatsucker, Night-jar, or Fern Owl*).—First seen August 31st, Over-Stowey, Bridgwater, H.S.B.G.

24. *Columba turtur* (*Turtle Dove*).—Nest, July 20th, Bridgwater, containing two eggs very slightly incubated, H.S.B.G.

25. *Perdix cinerea* (*Partridge*).—Nest with eight eggs at Kilve, May 26th, one pheasant's egg in nest also, H.S.B.G.

27. *Totanus hypoleucos* (*Common Sandpiper*).—Seen April 21st, on the river about a mile above Bridgwater; saw three on some old clay pits that were being filled up, July 6th, H.S.B.G.

28. *Crex pratensis* (*Corncrake or Landrail*).—Song May 4th, at Stowey, near Bridgwater; heard again the following day, H.S.B.G.

INSECTS.

Recorder : Geo. C. Griffiths, Clifton.

Abbreviations.—Ap. first appearance; G.c. getting common.

1. *Cicindela campestris* (*Tiger Beetle*).—G.c. May 26th, Leigh Woods; abundant in sunshine, and had probably been out several days.

2. *Melolontha vulgaris* (*Cockchafer*).—Ap. May 23rd, Portishead.

15. *Vespa vulgaris* (*Wasp*).—A large number of wasps visited the sitting-rooms, Caledonia Place, during September, and several nests were, I am told, noticed on Durdham Down.

17. *Pieris rapæ* (*Small Garden White or Cabbage butterfly*).—Ap. March 27th, Ashley Hill; seen by Mr. W. H. Britton flying over south border (1 specimen); April 18th, Tyndall's Park, one specimen seen by Mr. H. A. Smith; G.c. May 21st, abundant everywhere from May 21st to middle of June. I saw specimens of second brood July 17th, for the first time.

18. *Pieris napi* (*Green-veined White Butterfly*).—I did not see one specimen during the season.

19. *Pieris brassicæ* (*Large Garden White or Cabbage Butterfly*).—May 21st, Bristol; was much less common than usual this season.

20. *Anthocharis cardamines* (*Orange-tip Butterfly*).—Not observed during season.

21. *Epinephile janira* (*Meadow Brown Butterfly*).—Much less common than usual in Bristol district.

22. *Eriogaster lanestris* (*Small Egger Moth*).—Not observed.

23. *Amphidasys prodromaria* (*Oak Beaty Moth*).—Not observed.

24. *Tephrosia crepuscularia* (*Small Engrailed Moth*).—Ap. April 19th, Leigh Woods, one specimen, fine condition, probably just emerged. April 25th, Leigh Woods, two specimens, good condition; specimens taken at intervals up to May 27th.

25. *Tæniocampa Gothica* (*Hebrew Character Moth*);
26. „ *instabilis* (*Clouded Drab Moth*);
27. „ *stabilis* (*Common Quaker Moth*);
28. „ *cruda* (*Small do. do.*);
29. „ *munda* (*Twin-spot Moth*);

Leigh Woods, etc., abundant at Sallows, March 26th–28th, and probably earlier: Mr. Prideaux, Vyvyan Terrace.

30. *Brephos parthenias* (*Orange Underwing Moth*).—Ap. March 29th, abundant March 30th; G.c. March 30th, Mr. Prideaux.

31. *Diurnea fagella.*—Ap. April 4th, Leigh Woods, twelve specimens seen, all apparently newly emerged; G.c. April 7th, Leigh Woods, newly emerged; seen in considerable numbers during the whole of April.

The season of 1890 will be looked upon as one of the most unproductive of recent years, rivalling in that respect the cold, wet summer of 1888. The early spring was full of promise, and the number of larvæ which fell to our beating-trays during April and May was almost phenomenal; but with June a change seemed to come over the season, and from that time until late in autumn it was most disappointing. July and August are almost perfect blanks in my diary as far as outdoor work is concerned; on the 12th August a friend and I sugared a large number of trees in Leigh Woods, and found not one single moth; on the 20th of that month I again tried, and found only four specimens of the commonest species. Sugar as a mode of capture seems to have been an utter failure in almost all localities. Ivy-bloom also was quite unproductive at its first appearance, and up to the middle of October; after that time, however, it improved in a rather remarkable manner, and many species were found in fair average numbers. The regular ivy-frequenting species were thus very late in their appearance, and it seems probable that many late summer and autumn insects were so; at Bournemouth during the last week in August, *Satyrus semele* were flying in beautiful, fresh condition, this being fully three or four weeks after their usual time of emergence from pupa. A study of irregularities such as these, in connection with meteorological and botanical observations during several years, might be of the greatest value in determining the causes which govern the abundance or scarcity of insect life.

Rainfall at Clifton in 1890.

By GEORGE F. BURDER, M.D., F.R.Met.Soc.

TABLE OF RAINFALL.

	1890.	Average of 38 years.	Departure from average	Greatest Fall in 24 Hours.		Number of Days on which ·01 in. or more fell.
				Depth.	Date.	
	Inches.	Inches.	Inches.	Inches.		
January . .	3·898	3·212	+0·686	0·514	26th	22
February .	0·579	2·213	−1·634	0·190	14th	4
March . .	1·109	2·252	−1·143	0·274	24th	11
April . . .	1·140	2·117	−0·977	0·270	23rd	13
May . . .	1·869	2·399	−0·530	0·749	9th	13
June . . .	3·021	2·551	+0·470	0·437	29th	16
July . . .	3·411	3·051	+0·360	1·175	17th	18
August . .	2·932	3·410	−0·478	0·734	9th	21
September .	1·431	3·238	−1·807	0·566	17th	11
October . .	1·673	3·561	−1·888	0·506	7th	15
November .	2·551	3·050	−0·499	0·503	6th	18
December .	1·300	2·834	−1·534	0·335	20th	13
Year . . .	24·914	33·888	−8·974	1·175	July 17th	175

Remarks.—From the table it will be seen that the rainfall of the year 1890 was seriously deficient, amounting to barely 25 inches, and falling short of the average by nearly 9 inches. The deficiency was even greater than in 1887, which will be remembered as a very dry year. So small an annual fall has not been recorded since 1870, when the total was 23·429 inches. In 1864 a still smaller amount was collected, namely, 22·746 inches, and that was the driest year in a period of 38 years.

It is worthy of note that of the last four years three have been marked by a considerable deficiency of rain, and one by a trifling excess. The average annual deficiency during the four years has been about 5 inches, or nearly 15 per cent.

Regarding the rainfall of the past year in detail, we find that three of the months—January, June, and July—presented an excess of rain, but the excess was in no case large. The other nine months were all short of the average. January was the rainiest of the months, February was the driest; the former yielding nearly four inches of rain, the latter not much more than half an inch.

Notwithstanding the general dryness of the year, the distribution of the rainfall was such that indications of drought were seldom conspicuous. In the summer months, when from various causes a deficiency of rain attracts special attention, the weather was frequently unsettled and showery, and at no time of the year was there any such prolonged absence of rain as characterised the year 1887. The longest intervals of nearly rainless weather were—(1) from January 28th to February 14th (17 days); (2) from February 19th to March 7th (16 days); and (3) from August 29th to September 17th (19 days). In neither of these periods did the downfall amount to more than a few hundredths of an inch.

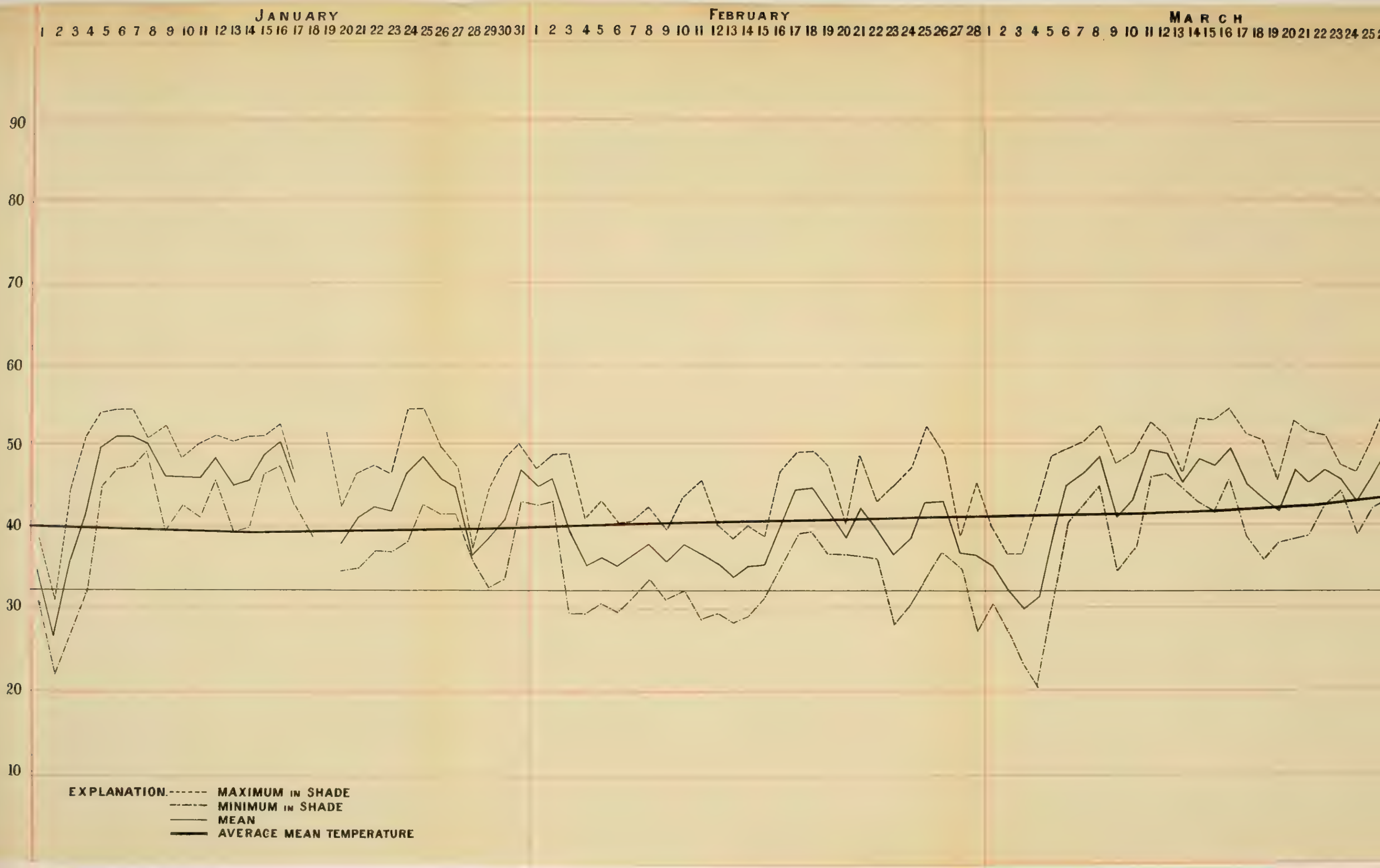
Snow (the melted equivalent of which is always counted as rain) fell on the 18th to the 21st of December to an average depth of eight inches. This was the only heavy snow of the year.

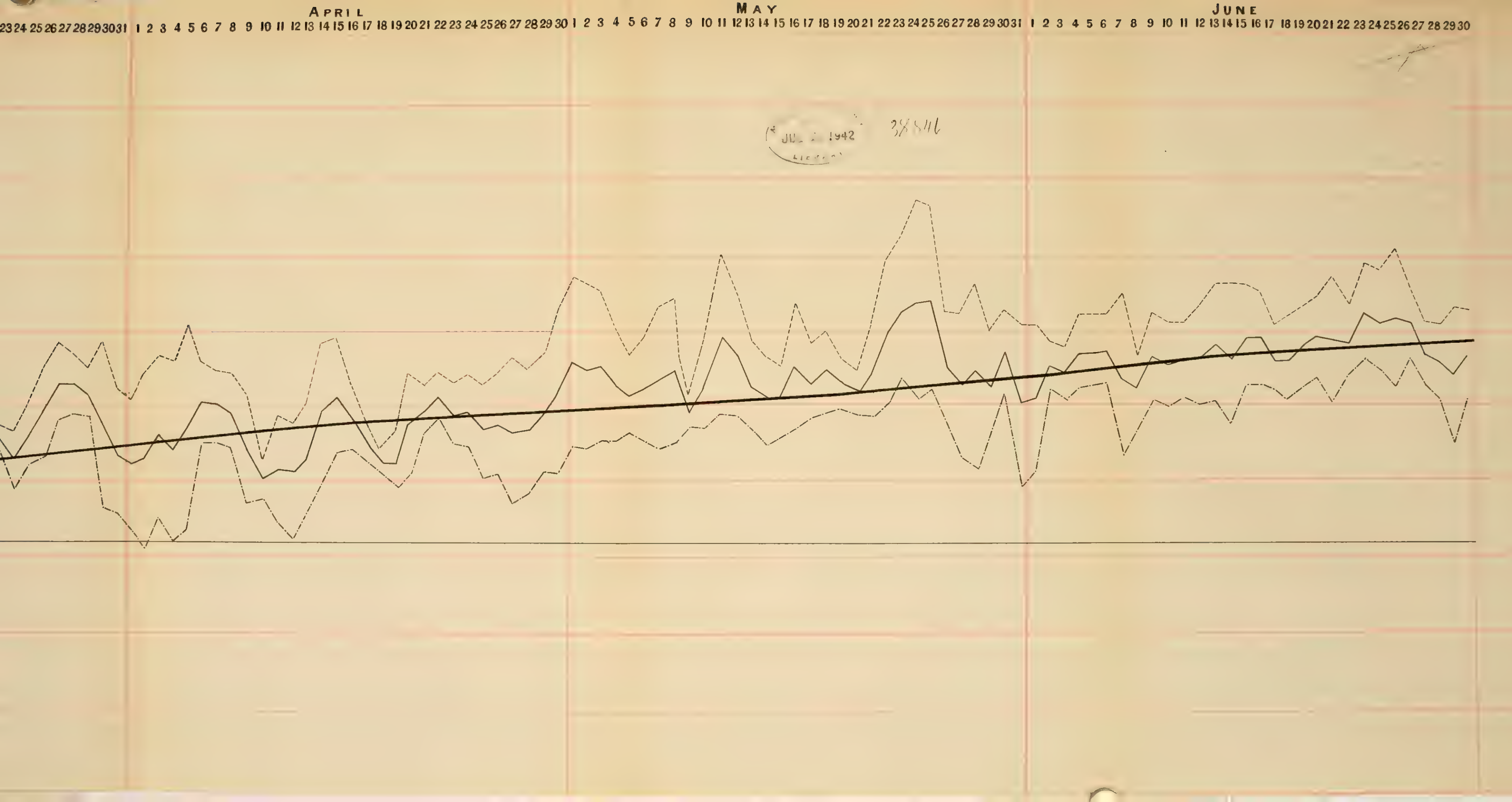
Observations of Temperature at Clifton College, 1890.

By D. RINTOUL, M.A.

THE following tables and diagrams contain a general record of the temperature of the year. It will be seen that the mean temperature is slightly above the average of the last ten years. The month of January was much warmer than usual, the mean temperature being 4·35° higher than the normal. The year, however, is distinguished most for the remarkably cold weather, which commenced on the 25th of November and continued without intermission till the 22nd of January, 1891. The mean temperature of December, it will be seen, is more than nine degrees lower than the average, and no December in the last ten years has had a mean temperature approaching it within eight degrees. The mean daily temperature was below the average on every day from the 25th of November till the end of the year, and not only so, the maximum daily temperature never rose so high as the average *mean* daily temperature during that time. The mean temperature was below freezing point from the 9th of December till the end of the year, and on fourteen days the thermometer never rose above freezing point. In this way the winter of 1890–1891 will long be memorable for its long-continued frost.

The diagrams show the daily maximum and minimum temperature in the shade, the intermediate line being the course of mean temperatures and the smooth curve representing the average temperature deduced from observations by the late Dr. Thomson of College Road—observations extending over more than twenty years.


JANUARY
FEBRUARY
MARCH
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
90
80
70
60
50
40
30
20
10
EXPLANATION
MAXIMUM IN SHADE
MINIMUM IN SHADE
MEAN
AVERAGE MEAN TEMPERATURE



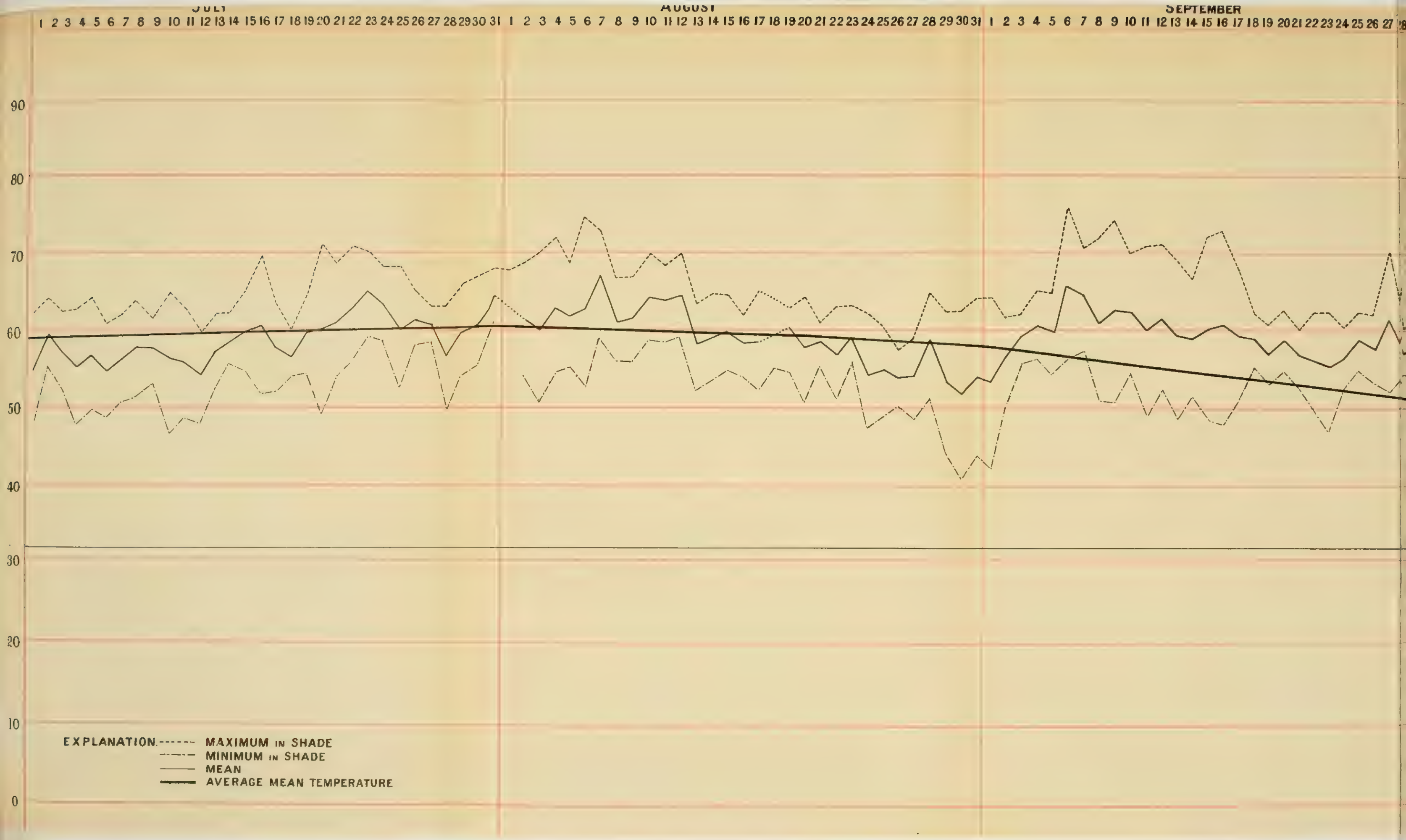
JUL 1942
38846

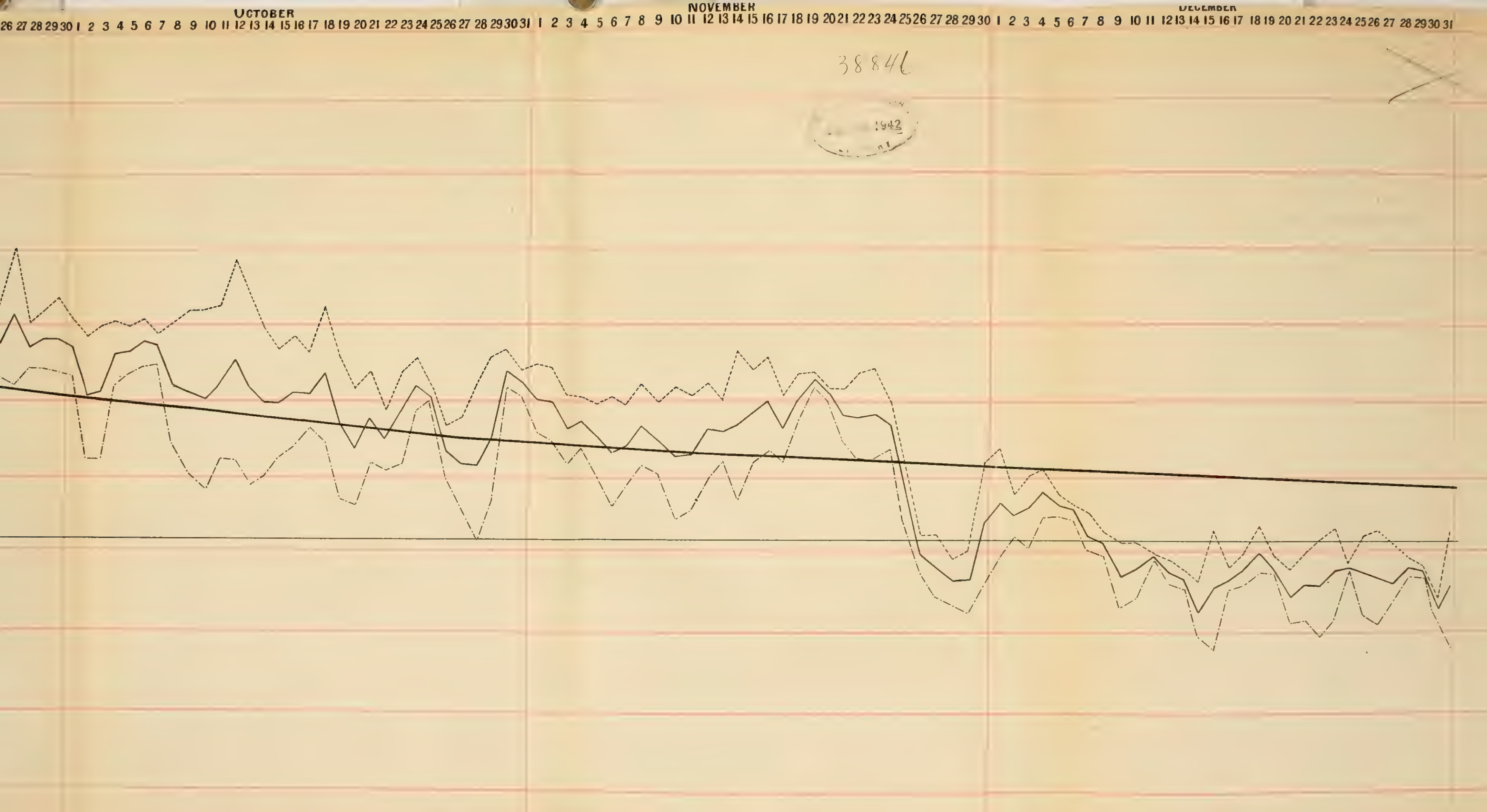
1890 TEMPERATURES.

MONTH.	Maximum in Shade.		Minimum in Shade.		Mean in Shade.	Minimum on Ground, lowest recorded.
	Highest recorded.	Mean.	Lowest recorded.	Mean.		
January .	54·3	48·49	21·8	39·04	43·76	21·1
February .	52·1	44·33	26·9	33·09	38·71	24·3
March . .	59·3	50·23	20·4	39·14	44·68	18·8
April . .	63·6	53·62	31·0	41·04	47·33	27·3
May . . .	77·3	62·98	39·3	46·87	54·92	37·2
June . .	71·3	63·76	41·8	51·32	57·54	38·0
July . . .	71·0	65·03	47·0	53·25	59·14	44·5
August .	74·1	65·76	41·5	53·00	59·38	39·7
September	76·0	66·53	42·1	52·81	59·67	39·1
October .	69·1	57·98	32·0	44·53	51·25	27·0
November	57·3	49·91	23·7	39·80	44·88	23·7
December.	44·5	33·28	19·1	26·97	30·12	17·2
Year 1890.	76·0	55·16	19·1	43·40	49·28	17·2
Year 1889.	80·5	55·22	22·2	43·60	49·41	18·2
Year 1888.	79·1	54·19	22·3	42·74	48·45	18·0
Year 1887.	82·8	56·0	20·4	40·9	48·4	11·7
Year 1886.	83·5	54·90	21·7	43·17	49·03	15·3
Year 1885.	87·8	53·98	22·1	42·53	48·09	20·1
Year 1884.	87·5	57·44	22·6	44·07	50·66	23·7
Year 1883.	82·5	54·54	20·9	42·88	48·71	19·3
Year 1882.	78·5	55·46	21·9	43·62	49·54	20·6
Year 1881.	86·9	55·44	12·3	42·92	49·18	5·8

MONTH.	Number of Days on which the Minimum Ground Temperature was below 32°F.	Number of Days on which the Minimum Air Temperature was below 32°F.	Number of Days on which the Maximum Air Temperature was below 32°F.	Number of Days on which the Mean Air Temperature was below 32°F.
January . .	8	4	1	1
February . .	17	15	0	0
March . . .	9	5	0	3
April . . .	10	1	0	0
May . . .	0	0	0	0
June . . .	0	0	0	0
July . . .	0	0	0	0
August . .	0	0	0	0
September .	0	0	0	0
October . .	1	0	0	0
November .	7	5	2	4
December .	27	27	13	23
Year 1890 .	79	57	16	31

Year 1889 .	88	45	5	12
Year 1888 .	93	60	2	16
Year 1887 .	148	63	2	11
Year 1886 .	102	64	1	22
Year 1885 .	68	40	1	6
Year 1884 .	51	19	0	1
Year 1883 .	79	40	0	6
Year 1882 .	63	26	2	7
Year 1881 .	94	60	11	24


JULY
AUGUST
SEPTEMBER
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27
90
80
70
60
50
40
30
20
10
0
EXPLANATION
MAXIMUM IN SHADE
MINIMUM IN SHADE
MEAN
AVERAGE MEAN TEMPERATURE


26 27 28 29 30
OCTOBER
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
NOVEMBER
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
DECEMBER
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

38846
1942

MEAN SHADE TEMPERATURES OF THE MONTHS.

MONTH.	1881.	1882.	1883.	1884.	18 5.	1886.	1887.	1888.	1889.	1890.	Mean of Ten Years.
January . .	31·8	40·7	42·3	44·2	38·7	35·5	41·5	38·5	37·16	43·76	39·41
February .	39·3	42·6	43·3	42·3	44·0	35·8	41·0	36·1	38·96	38·71	40·20
March . .	43·0	45·7	37·0	44·9	41·7	40·1	39·9	38·6	41·50	44·68	41·70
April . . .	47·3	48·8	47·5	45·1	46·7	46·4	42·2	44·1	46 07	47 33	44·14
May . . .	54·4	53·7	49·9	53·3	47·0	52·2	45·5	52·5	55·79	54·92	51·98
June . . .	56·9	56·0	57·2	59·8	58·4	58·8	62·4	57·9	61·29	57·54	58·62
July . . .	65·9	59·6	57·2	60·7	62·6	62·7	63·9	58·4	61·08	59·14	61·12
August . .	58·8	60·2	60·6	64·5	57·5	59·1	60·4	59·3	59·18	59·38	59·89
September .	56·6	53·9	55·3	59·4	54·5	58·2	53·7	57·3	56·93	59·67	56·55
October . .	46·5	50·2	49·6	48·9	45·6	52·9	46·1	48·8	43·79	51·25	48·86
November .	48·3	43·7	42·8	41·6	43·3	47·1	41·2	47·2	46·72	44·88	44·67
December .	40·8	39·8	41·4	43·1	38·8	38·6	39·9	42·7	39·44	30·12	39·45
The Year .	49·2	49·5	48·7	50·7	48·1	49·0	48·4	48·45	48·41	49·28	49·06

The Frosts of Recent Years.

BY GEORGE F. BURDER, M.D., F.R.MET.SOC.

THE unusual severity of the weather during a portion of the past winter may give an interest to the following brief summary of the more remarkable frosts that have occurred within the writer's experience. It is to be understood, when nothing to the contrary is stated, that the temperatures given are from observations at Clifton.

1. The weather in January, 1838, was historical for severity, and the frost continued with less intensity and with some interruptions through a good part of February. From the Greenwich records it has been gathered that the 41 days from January 8th to February 17th had a mean temperature of 26·7, and that the mean of the 12 days from January 9th to January 20th was 20·3. The coldest day by far was the 20th of January, when the thermometer at sunrise stood within 3 degrees of zero (the self-registering instrument having failed), and the mean temperature of the 24 hours was no higher than 10·7. The Thames below London Bridge was frozen from shore to shore, and on one day at least persons crossed on foot. There is no doubt that this frost was very severe here also. At Stroud a temperature of 5 degrees was observed.

2. In January, 1841, there was a period of 8 days (from the

3rd to the 10th) when the mean temperature at Greenwich was 23·9, and the minimum 4 degrees. From imperfect observations at Stroud it would appear that this frost was less severe in the West of England, although still sufficient to admit of skating.

3. A frost of remarkable severity for the time of year occurred in March, 1845. At Greenwich the mean temperature of the 15 days from the 4th to the 18th was 29·0, and in this neighbourhood the mean of the same period was approximately 28, a minimum of 11 being observed on March 14th. There was skating as late as the 21st of March on the lake at Stoke Park, the ice being from 4 to 5 inches thick.

4. The winter of 1853–54, although not on the whole severe, included a remarkable frost of 13 days, from December 25th to January 6th. The mean temperature of this period at Clifton was 28·5, and the two lowest temperatures observed were 10·7 on December 29th, and 15·0 on January 3rd. At Nottingham on the latter day Mr. Lowe registered a minimum of 4 degrees below zero. A heavy, drifting snowstorm occurred on the night of January 3rd, blocking the railways to such an extent that during two days no trains passed between London and Liverpool. It was less felt here than in some other parts of the country.

5. The following winter (1854–55) was extremely severe. The great frost of that season may be said to have extended over 41 days, namely from January 15th to February 24th. The mean temperature of this long term was 28·6, and the mean of the 12 days when the frost was at its greatest intensity, namely from February 10th to February 21st, was as low as 23·3. The lowest temperature noted here was 11·5 on February 18th. The mean temperature of the month of February at Clifton was 29·3, and at Greenwich that month

has the distinction of being the coldest February in a record of 120 years. The monthly mean at Greenwich was 29·4. Towards the end of the frost our Floating Harbour was firmly frozen, and afforded excellent skating on the part below Prince Street Bridge.

6. In December, 1855, a frost, which lasted 4 days only, gave us a minimum of 13·2 on the 22nd, and a mean for the period (December 19th to 22nd) of 26·3.

7. A frost, considerably more severe than the last named, and of somewhat longer duration, occurred in December, 1859. The 7 days from the 14th to the 20th of that month had a mean temperature of 23·1, and the minimum on the 19th was 10·2.

8. In the winter of 1860–61 there were two severe frosts, separated only by a three days' thaw. The 11 days from December 19th to December 29th had a mean temperature of 25·4. The 10 days from January 2nd to January 11th had a mean of 25·9. If we consider the two frosts as one frost with a break, we find the mean temperature of the whole period of 24 days to have been 27·3. Three extremely low minima were recorded—namely, on December 25th, 11·1; on December 29th, 7·1; on January 7th, 9·7. In many places the frost on Christmas Day was the most severe, the thermometer at several stations falling below zero. At Nottingham Mr. Lowe recorded a minimum of 8 degrees below zero.

9. In January, 1865, we had a 10 days' frost, the mean temperature from the 20th to the 29th day being 30·1, and the minimum on the 29th, 13·5. On the same day a thermometer lying on the snow registered 6·0.

10, 11. In January, 1867, there were two continued frosts, both worthy of mention. The first 5 days of the month had a mean temperature of 26·5, with a minimum (on the 4th) of

14·1. The 11 days from the 12th to the 22nd had a mean of 28·0, with a minimum of 19·2 on the 15th.

12. In March, 1867, a frost occurred which was severe for the time of year. The 8 days from March 12th to March 19th had a mean temperature of 31·4, and a minimum (on the 17th) of 23·2. On the 19th snow fell very heavily, and lay on the ground to an average depth of 12 inches.

13. The winter of 1870–71 was marked by a hard frost of 15 days' duration. From the 21st of December to the 4th of January the mean temperature was 24·8, and the minimum on the 1st of January was 10·0.

14. In 1874–75 a frost which set in December 15th lasted with partial intermissions until January 1st. The mean temperature of those 18 days was 30·0, and the minimum (on December 31st) was 13·6.

15, 16, 17. The winter of 1878–79 was the first of three winters, all of which were distinguished in one part or another by an exceptional degree of cold. In 1878–79 a heavy snow on the last night of October ushered in a winter which later on included three frosts, each of considerable duration. Between December 8th and December 25th there were 18 days with an aggregate mean temperature of 30·3; between January 5th and January 12th, 8 days with a mean of 26·9; between January 20th and February 1st, 13 days with a mean of 30·6. The lowest temperature of the season was 16·4 on January 12th. There was skating in this neighbourhood as early as December 11th.

18, 19. In 1879–80 there were two continued frosts: the one from November 30th to December 12th, 13 days with a mean of 29·8; the other from January 18th to January 28th, 11 days with a mean of 28·7. The early date of the former of these frosts was its most striking feature. Skating was reported in the neighbourhood of Bristol on the 2nd of December. The lowest minima noted here in that winter were 19·2 on December 7th, and 18·4 on January 21st. Much lower temperatures were reported from other stations.

20. The winter of 1880–81 was not severe save in the month of January, but that was a month of unusual rigour. The mean temperature of the whole month was 30·9, and the mean of a period of 19 days, from the 8th to the 26th, was as low as 25·5. A minimum temperature of 12·8 was registered here on the 22nd of the month, and on the same day a thermometer placed on the snow fell to 3·5. A violent snowstorm and gale on the 18th and 19th blocked the railways to a degree beyond any previous experience.

21. In March, 1886, a frost, severe for the time of year, lasted 11 days, from the 7th to the 17th, with a mean temperature of 31·6. This frost derives additional importance from having been the culmination of a prolonged period of cold weather, with a mean temperature but little above the freezing point. Thus the first 17 days of March had a mean temperature of 32·2, and the period of 31 days from February 15th to March 17th had a mean of 32·6.

22. In March, 1887, we had another experience of very wintry weather late in the season. The mean temperature of the eight days from the 13th to the 20th of that month was 31·8, and on the 15th we had the heaviest snow, as measured by the average depth, that is known to have occurred in this part of the country. This snow was but little drifted, and lay to a nearly uniform depth of 15 inches.

The Frost of 1890–91.

The month of December, 1890, had a mean temperature at Clifton nearly identical with that of January, 1881, namely, 31·0. But such a temperature in December is much more rare than in January. The coldest December in a record of 120 years had a mean temperature of 29·0. The coldest January had a mean of 23·9. These very rare extremes occurred respectively in the years 1788 and 1795.

The frost which thus reduced the mean temperature of the entire month to within two degrees of the coldest December on record may be said to have set in on the 9th day, and to have continued till the 31st. There had been very cold weather about the end of November, but this was separated from the December frost by a comparatively mild interval. The 23 days from December 9th to the end of the month had a mean temperature of 28·8, and the minimum of the period was 18·8 on the 15th.

The commencement of the new year witnessed a sensible mitigation of the cold, and on several days in the first half of January there was a rather decided thaw. The night temperatures, however, continued low, and the frost did not finally break up until the 20th of January, the two previous days—the 18th and 19th—being the coldest of the season. The minimum on the 18th was 18·0; on the 19th, 15·5. The mean temperature of the first 19 days of January was 30·7.

Combining the last 23 days of December with the first 19 days of January, we get a period of 42 days with a mean temperature of 29·7.

It may be worth while to take a yet more comprehensive view. A rapid and continuous fall of temperature set in on the 24th of November, 1890, and from the 25th of November to the 19th of January following, it is doubtful if there was a single day the mean temperature of which was not below the average. Regarding this period of 56 days (or just 8 weeks) as one of continued cold, although not of continued frost, we find its mean temperature to have been 30·9 degrees. This is perhaps the most remarkable feature of the season.

Subjoined is a table in which the principal points of the several frosts referred to in the foregoing account are exhibited in a form convenient for comparison.

TABLE OF FROSTS.

No.	Winter.	Duration.	Days.	Mean Temp.	Min. Temp.	Date of Min. Temp.
1.	1837–38	Jan. 8–Feb. 17	41	26·7	3 (or lower)	Jan. 20
		(Jan. 9–20	12	20·3)		
		(Jan. 20	1	10·7)		
2.	1840–41	Jan. 3–10	8	23·9	4	Jan. 8
3.	1844–45	Mar. 4–18	15	28	11	Mar. 14
4.	1853–54	Dec. 25–Jan. 6	13	28·5	10·7	Dec. 29
5.	1854–55	Jan. 15–Feb. 24	41	28·6	11·5	Feb. 18
		(Feb. 10–21	12	23·3)		
6.	1855–56	Dec. 19–22	4	26·3	13·2	Dec. 22
7.	1859–60	Dec. 14–20	7	23·1	10·2	Dec. 19
8.	1860–61	Dec. 19–Jan. 11	24	27·3	7·1	Dec. 29
		(Dec. 19–29	11	25·4)		
		(Jan. 2–11	10	25·9	9·7	Jan. 7)
9.	1864–65	Jan. 20–29	10	30·1	13·5	Jan. 29
10.	1866–67	Jan. 1–5	5	26·5	14·1	Jan. 4
11.	,, ,,	Jan. 12–22	11	28·0	19·2	Jan. 15
12.	,, ,,	Mar. 12–19	8	31·4	23·2	Mar. 17
13.	1870–71	Dec. 21–Jan. 4	15	24·8	10·0	Jan. 1
14.	1874–75	Dec. 15–Jan. 1	18	30·0	13·6	Dec. 31
15.	1878–79	Dec. 8–25	18	30·3	21·2	Dec. 15
16.	,, ,,	Jan. 5–12	8	26·9	16·4	Jan. 12
17.	,, ,,	Jan. 20–Feb. 1	13	30·6	22·3	Jan. 23
18.	1879–80	Nov. 30–Dec. 12	13	29·8	19·2	Dec. 7
19.	,, ,,	Jan. 18–28	11	28·7	18·4	Jan. 21
20.	1880–81	Jan. 8–26	19	25·5	12·8	Jan. 22
21.	1885–86	Feb. 15–Mar. 17	31	32·6	21·6	Mar. 7
		(Mar. 1–17	17	32·2)		
		(Mar. 7–17	11	31·6)		
22.	1886–87	Mar. 13–20	8	31·8	21·0	Mar. 17
23.	1890–91	Nov. 25–Jan. 19	56	30·9	15·5	Jan. 19
		(Dec. 9–Jan. 19	42	29·7)		
		(Dec. 9–31	23	28·8	18·8	Dec. 15)

On Landslips.

By CHARLES RICHARDSON, C.E.

MY first practical knowledge of landslips was obtained from those of the "Swindon bank" of the Cheltenham and Great Western Railway. The portion of this railway from Swindon to Cirencester, 18 miles in length, was first proceeded with, Mr. Brunel having placed me in charge, as Resident Engineer, in January, 1838.

In this portion of the line there was a big embankment, at the Swindon end, the best part of two miles in length, and passing over some flat meadow lands at a height of full thirty feet. As there was no big cutting adjacent to it from which the stuff would naturally be obtained, it was formed from side-cuttings on both sides.

The top width of the bank, under ballast level, was 40 feet, the slopes $1\frac{1}{2}$ to 1, and the bottom width, on the turf, therefore, 130 feet; then an additional width or recess of 12 feet of turf was left, on each side, before the slope of the side-cuttings began, the side-cuttings being each 10 feet deep and 150 feet wide.

The lower part or base of this bank was formed, by barrow-work from the side-cuttings, during the wet summer of 1839—the most continuously wet summer I recollect. It was made rapidly, for any number of men could be put to work upon it. The geological formation is Kimmeridge clay

—an easily grafted material, but the most *slippery* stuff I have ever had to deal with.

The result naturally following the use of such a material, put together by barrow-work during such a rainy time, was, that when the line was ready to be opened in 1841, a number of serious slips had taken place in this bank; but they were all on the eastward side of it. So it was decided to lay the permanent way only upon the western side of this bank, and to work the traffic there upon a single line (the rest of the line being double) until we had cured the slips upon the east side.

The largest of the slips were about 110 yards in length; breaking away, on top, from near the middle of the bank, and, at bottom, carrying forward the recess (or "cess" as the men called it) along with them. Thus the total perpendicular depth of the slips was 40 feet. The clay was, in fact, sliding back into the side-cutting from which it had been dug, and carrying forward the "cess" with it. The "cess" preserved its level, but was shoved gradually forward into the side-cutting—fastest in the central parts, and more and more slowly towards the ends. Here it may be well to describe the "slipping surface," a most important feature, with which I afterwards became familiar. I found that slips always form a conchoidal "slipping surface," nicely lubricated, and as smooth and polished as the inside of a marine shell, on which the mass slides slowly downwards. By digging down into the slip this "slipping surface" is always readily detected, the material naturally breaking away from it. Its vertical form is always conchoidal; starting from a nearly upright face on top, it forms a graceful curve down to a nearly level surface at bottom.

When the time came to decide upon what should be done to stop these slips, Brunel came down, and, after inspecting them carefully, made up his mind to drive a row of strong piles along the "cess" as rapidly as possible; and, being a man who never allowed the grass to grow under his feet, he obtained and sent down half a dozen lofty pile engines with 30-cwt. monkeys, and piles were obtained by buying some very straight-grown young beech-trees from the woods in the neighbouring Chalford Valley. These piles were not less than 10 inches in diameter, and were cut into 20-feet lengths. Everything was on the ground in three or four days. The "cess" made a capital floor for the pile engines to stand upon; the piles went easily through this plastic clay, each engine being able to drive ten or a dozen piles in the day; so in less than a couple of days all the piles upon a 100-yard slip were driven in a row. But the slip took *no notice* of them, and the pile heads, which stood up a foot or so above the ground, kept on advancing in line along with the "cess," but with an increasing prominence of curvature in the centre.

The idea of pinning down the "cess," which was gradually moving forwards, to the ground below, which was not moving, and so stopping the advance of the slip, was so obvious that it was quite natural that piles should be the first thing tried, and every one was surprised that they should have entirely failed to produce any effect.

Now, these slips seldom advanced at a greater speed than an inch in an hour, a movement quite imperceptible to the eye. This was about the rate of this slip, and yet it progressed with such force as to shear off these green beech piles at the "slipping surface," 10 feet below the "cess," without the smallest apparent check—a fact which at first exercised my mind very much. The piles had, I knew, gone into the *sound* ground below the slip to a depth of eight feet; and how could that soft clay form a cutting-edge by which to shear off the tough and stringy green beech piles? Afterthought, however, convinced me that this power was given to it by the enormous weight of the superincumbent load, about 200 tons upon each pile. I afterwards had an opportunity of setting this matter at rest by drawing a good many of the piles, when I found that they had been torn sheer across at the "slipping surface," but leaving a ragged, fibrous fracture, showing the toughness of the timber.

Piles having been thus proved to be of no avail, Brunel allowed the contractor to try a plan of his, by making fire holes in an arched form with flues between the holes, filling them with wood and coal, and burning the clay, thinking to get the strength of the *arch* to sustain the slip; but though the holes were 8 or 9 feet deep in the bank, his arch was altogether too superficial, and the whole rode away upon the slip together, and did no good. Some other schemes were tried or suggested, which are not now worth alluding to further.

In the meantime I had been thinking over another scheme, which I put before Brunel on the occasion of his next visit, and which he at once consented to let me try.

Two miles to the north of this big bank we had a short rock-cutting in the coral rag formation, very suitable for my purpose, and we had a new 100-yard slip in the bank, just started and well under way, on which to try it. My plan was: To dig some holes, each 6 feet square and 6 feet apart, in the "cess"—close up to the slope of the bank; to carry them down to a depth of a foot or 18 inches below the "slipping surface" into the unmoved ground below, and then to fill these holes with the rough stone from the coral rag. But, as it was of the greatest importance to get these holes excavated and then filled with stone as rapidly as possible,—for the holes themselves would greatly weaken the foot of the slip while they were still open,—I only had the alternate holes dug first, intending to put down the intermediate ones afterwards, so as not to weaken the slip too much at one time. Thus the first set of holes put down were six feet square and twenty-four feet apart from centre to centre.

By the time these holes were down, I had a train of wagons full of stone on the bank, and men ready to chuck the stone in at once, for we had plenty of men and of wagons; thus the holes were filled simultaneously. But in digging the holes a novel plan was adopted to save time. Though the stuff was a nice grafting clay, yet a grafting tool is very heavy, and a navvy can only cast his graft to the height of his shoulder, about five feet say; so to get down 12 feet he would have had to fix two stages on which to cast the grafts, and the process would be too slow. I therefore organized a new plan of working. I put one stout navvy with his grafting tool into each hole, and a young active countryman with him with a short-handled pitchfork. The navvy had only to turn the grafts over; then the countryman stuck in his pitchfork (which is a comparatively light tool), and flung the clod over his left shoulder; and this they were able to do comfortably from the bottom of the hole, the navvy taking rather lighter grafts when the hole was deep. The work thus went on with remarkable speed; for the navvy had only to turn the grafts over, and the man with the pitchfork to fling them out as quickly as the other grafted them; for the lumps of clay slipped from the fork beautifully, and the men were quite pleased with the arrangement. For fear of the clay sides of the holes falling in, I had some three-inch planks ready, cut to the lengths in sets of four, two 6 feet long, and two 5 feet 6 inches. About five feet down the longer planks were placed against the back and front of the hole, and the shorter ones wedged in between them, in a few minutes. The second set was similarly wedged in about nine feet down, or a foot above the "slipping surface." A man on top was looking after and spreading the cast-up clods, and took his turn at casting up with the pitchfork occasionally, for that was the hardest work. The holes were easily got down thus in one day, and the clay stood for this short time perfectly as a rule, so that the men thought there was no need to use the timber; but I had them put in as a precaution, for if any side had fallen in, it would have spoilt the "stone counterfort," as the men christened them. Thus these twelve counterforts, two yards square and six yards clear apart, were got in in a day and a night; for the stone was all on the bank ready, and was put in during the night.

The effect was immediate, and, in its extent, unexpected; for in explaining my plan to Brunel, I had insisted upon the important effect of the rough stones, if dragged along by the slip, roughing up the smooth and glossy "slipping surface," and causing soon so much friction as to stop its progress: for I did not feel that I was able to form any definite opinion as to the immediate resistance of a pile of loose stones as a counterfort against the enormous pressure of the slip, as proved by the simultaneous shearing of all the beech piles.

The result, however, proved that all the force of the slip could not move the counterforts in the least—it was stopped dead, and at once, as I had the means of knowing by my marked pegs which I had driven for the purpose of exactly measuring its progress. The alternate holes were never wanted, and were never put down. But the effect of this extremely sudden check to the motion of the slip on the east side, while under full and steady way, appeared to be, as by a sort of rebound, the starting of a similar slip on the west side of the bank, exactly opposite the other.

As the west side had to carry the single line then opened for traffic, and as this west-side slip went down four or five times as fast as the other, it caused great trouble and excitement. Brunel was determined to keep the traffic going, and arranged for train-loads of sand from Swindon to be brought there between the passenger trains. The sand was cast out by a crowd of men to keep the working line constantly raised, but the slip went down still faster; so large quantities of fagots were also brought down, and the line raised by placing beds of fagots, close together, under the sleepers, and then tipping sand over the fagots, to steady them.

I was on the bank night and day during the worst time, and saw the trains over. We sometimes lifted the rails quite three feet between two trains, packing the fagots under the timber and then tipping sand among the fagots. It was a "broad gauge" line laid upon longitudinal timbers, otherwise it could not have been kept safe for the trains, and I took particular care to keep the rails in a straight line, well to gauge and level across.

We could not keep the road up to its proper level; and, thus, at the worst times, it was 8 or 9 feet below its due level in the middle of the slip; but I eased off the gradients at the ends to make them less steep, and in this condition the line took passengers across for many days, until we had succeeded in checking the progress of the slip by our appliances at its foot. In the meantime, however, the descent the trains had to go down was something fearful, and most of the engine-drivers went at it so timidly that I was afraid they would never get up the hill again on the other side; for if they had come to a stand there, they would never have been able to get out again without assistance. There was, however, one very plucky driver, Jack Hurst, whom the other men nicknamed "Hell-fire Jack." He always looked for me as he came up to the slip, and when I gave him the signal "All right," he put on steam boldly and went over it without trouble. He made the offer to stay there and take all the trains over, as the other men were afraid; but he was not allowed to do this.

After a big lift of the road, and a quantity of fresh fagots and sand had been put under to pack it up, these materials lay of course very hollow; so, as the heavy engine passed over it, the road sank down a couple of feet under the wheels of the engine as it ran over, much like a wave of the sea running along in front of the wheels; but there never was the least hitch or accident. Of course there were no "Board of Trade" regulations affecting railways in those days.

These slips cost the Company more than a quarter of a million of money.

In the neighbourhood of Wootton Bassett the Great Western Railway passes through a considerable length of the same Kimmeridge clay formation, and there they had very great difficulties with the landslips. These slips were in progress at the same time, though they had begun some months before those in the Swindon bank; but the Wootton Bassett banks being deeper, the slips were more formidable —both sides of the bank slipping at the same time and leaving a wedge-shaped piece between them. Many piles were driven there, with, I have no doubt, very little service, as in my case, until at last rows of very strong piles were driven in pairs opposite each other and about half-way down the batter of the slope, and the tops of each pair were then tied together by strong chain-cables; but with what amount of success I did not learn, though not much, I should judge, from after-appearances; for it is evident that enormous quantities of earth had to be tipped against and upon the toes of these slips, until the banks there had become enormous works, as may now be seen in passing along the railway. The cuttings, also, through the same material, gave great trouble for some years afterwards, new and large slips constantly occurring after wet weather, and many hundreds of thousands of yards having to be run away after the opening of the railway. The contractor, Brotherhood, who had the maintenance of the way there for many years, used to tell of an oak tree which, when the line was first made, grew upon some higher ground, nearly a quarter of a mile off the line. This tree, as the slope of the cutting slipped, kept on slowly advancing towards the line, always preserving its upright position, until at the last, when it was cut down, the branches fell across the rails.

In passing along this part of the line, any one accustomed to the appearance of landslips will observe that all the meadows round about display everywhere the forms of natural landslips, which, I have no doubt, still advance a little more continually, after wet seasons, up to the present time.

CHALFORD VALLEY SLIPS.—There were some characteristic landslips on another portion of the same Cheltenham and G.W. line of railway, subsequently constructed under my charge, where it passes down the Chalford Valley. This is a narrow valley cut through the oolitic formation. The bottom is little more than 100 yards in width, and the sides are very steep—in some places as steep as 3 to 1.

Before the railway was made down it, this narrow valley was already crowded with the Thames and Severn Canal and towing-path; with the turnpike road, with the river, and with the mill-ponds and tail-waters of the numerous cloth mills there constructed, so that there was but little elbow-room along it for the railway works.

The railway passed along from 50 to 100 feet above the bottom of the valley, at which level the geological formation was the inferior oolite, a white rock in nearly level beds. This rock reached to a level of perhaps 150 feet above that of the railway, at which level the fuller's-earth formation, 80 feet thick, came in—a dark blue formation, chiefly made up of beds of fuller's-earth clay, but with many beds of blue rock among it. Above this again were the white rocks of the great oolite, which formed the top of the hill.

The fuller's-earth clays formed the slipping material, and when I first went there, I noticed some old natural landslips here and there all down the valley. It is not a bad ground, however, and only slipped where it had great provocation; that is where, in the steep valley slopes, copious water-springs burst forth. These slips, consequently, came to a stand with comparatively steep, rounded contours, and caught the eye of the observer instantly.

I may now proceed to describe the most interesting and instructive one amongst those affecting the railway. The rough sketch of it, which I have made from memory, will help you to understand its position.

This slip takes its origin in a large wood, many feet above the railway, where the slip, in its origin, spreads out to a breadth of a quarter of a mile or more. In seeking through the wood for the cause of the slip, I found there three separate and considerable water-springs, which came to the surface at different places; but, after running a few yards, they all disappeared again through the broken ground. These, no doubt, caused the slip. As this slip, however, in its subsequent steep descent, passes over the strong lower oolite, its boundaries become greatly narrowed, and the slip, now only 50 yards or less wide and 30 or 40 feet deep, passes down a steep gully in the rock below, till it arrives at the level meadow at the bottom of the valley, where it has formed a large, rounded mound, perhaps 60 feet high. There it appeared to have stopped, the bottom resistance having balanced the down-thrust. This mound must have been a remarkable object in the narrow valley, and must have afforded, from its top, a pretty view up and down the valley.

Now this valley was, early in this century, the seat of a great industry in the manufacture of cloth. It was filled with cloth mills and the workmen's houses. The masters of the mills also (then called "Clothiers") had built themselves, here and there, handsome houses. One of these men had selected as a site this little rounded knoll, and had built his house upon it—a very nice, well-built house, with all conveniences, and, amongst others, a strongly built well, whence he had a good supply of excellent water.

At the time the railway was made, this cloth trade had greatly declined, and many of the mills had been closed. The railway passed so near to this house that the fence-line cut off one corner of it; so the Company had to buy the whole of the premises, and in that house I lived during the construction of the works.

I soon observed that the house had been built upon an old landslip, and I shortly after had unmistakable evidence of the still constant though slight advance of the slip. The first intimation I had of this was during the night, when I was sound asleep in bed. There was a sudden report, much like a pistol-shot, in my room. This I afterwards found was caused by the breaking of a nail in the floor, as the slip drew one corner of the house faster than the other parts. Another time, a prominent moulding from the very handsome and projecting cornice to the ceiling fell with a startling crash upon the boarded floor.

On looking round the house for signs of the movement of the slip below, there were noticeable cracks in the walls and in the ceilings; and these latter all ran diagonally across the rooms, showing that one corner of the house moved faster than the other parts. This was quite consistent with the position of the house upon the slip, for in a slip the middle always moves faster than the sides, as in a stream of water, and one corner of the house was nearest to the middle of the slip. I soon became interested in these violent and sudden reports, which no longer startled me. They were, of course, most frequent after rainy weather. Another evidence of the former continuous advance of the slip was proved by the well. A good pump had been fixed in this well originally; but as the slip advanced, the masonry round the well was broken through at the level of the "slipping surface," and the part of the well above this fracture slowly but continuously advanced over the lower portion, until the pump itself was nipped between the opposite walls and, after a time, broken off—after which event no more water could be pumped up. This occurred before I was in possession, but I was afterwards told of it by the mason who did the repairs for the former owner.

The railway, when it was made, cut through the neck of the slip for a depth of about 25 feet: it did not go *through* it, but left a bit in the bottom, under the deepest part of which, doubtless, the stream of water ran down a channel in the original surface of the ground.

It was full of interest to watch the laying open of the old slip, as the cutting was excavated. The slip was composed entirely of the blue fuller's-earth clay at the bottom, but carrying some rough blocks of stone at or near the top. The "slipping surface" was peculiarly evident, as was also the ancient top soil which had been buried by the slip when it first came down. This old top soil rests upon 5 or 6 feet of oolitic *débris* overlying the white oolitic rock, as is usual in those parts having a rock subsoil; but, upon this old top soil, there was a coating of about six inches of the fuller's-earth clay under the "slipping surface," on which the slip moved downwards. The clay during excavation always broke away from and exposed the smooth and polished "slipping surface," which, in this case, was highly and strangely coloured with green, orange, and purple in stripes, showing the direction of the slip. These prismatic colours were the admiration of the navvies, and I put away a fine sample, but lost it on removal.

Before the railway was begun this slip had apparently come nearly to an equilibrium, for it was only perceived to move *a very little* during wet times. But after the railway had been made the condition of things was quite altered, and I pointed out to Brunel what I took to be the state of things *then*; namely, that the railway, by cutting through the neck of the slip, had altogether removed from it the buttress formed by the large lower mass, and that I was sure the slip would again advance, and with more rapidity, and thus endanger the railway. I accordingly proposed to him to drain the upper parts of the slip by a heading drain, at a cost of about £750; but he would not go to the expense.

The line was opened shortly afterwards, and then I went to take charge of the Hereford, Ross, and Gloucester line; but just when I went there had been some heavy rains, which set the slip moving again. It came down suddenly and with great pressure against the small portion of it which had been left under the railway. This small remainder could not shove forward the heavy lower mass on which the house had been built, so it squeezed up the part under the railway, as I had anticipated, and raised up the rails three feet in one night. It would have caused an accident had it not been observed very early in the morning. I understood they had a good deal of trouble with it afterwards, but the house below remained steady from that time.

In Herefordshire, where we were in the old red sandstone and marl, we had no slips; but on the New Passage line, which was the next under my charge, we had many. The worst part of this line was in the Ashley Hill Valley, up which the railway runs. After passing through the deep but short Narroways Hill cutting, where the formation is new red marl with some beds of rock, the line enters the aforesaid valley upon a high embankment.

Ashley Hill Valley Slips.—Now, in my preliminary walks along the line, I had noticed that both sides of this valley were covered with natural landslips, many of them showing quite recent movement. I anticipated great risk from these slips, particularly as the railway works were heavy, and I was prepared to take strong precautions. I had a local Board of Directors, of whom Mr. Christopher Thomas was the chairman; and I have no doubt Mr. Brunel had told them of my experience in the management of landslips, for they always, without hesitation, allowed me to do what I thought necessary as a provision against these movements, although the cost of the precautions was large, and they, as a Company, were very poor. We did not, consequently, have a serious slip anywhere along that valley.

The valley is in the lias clay, and with a watercourse at bottom. The sides have, evidently, sometimes here and sometimes there, kept on slipping downwards from time to time after heavy rains, until, on reaching the bottom, the slips were washed away by the brook, but not entirely, for I afterwards found that the slips had raised the level of the brook many feet.

After passing through Narroways Hill cutting, the line crosses the "Boiling Wells" Valley on a 50-ft. embankment, over a flat, swampy ground, which, on trial, I found to be made up of lias slip-clay, washed down there by the brook, and some peat on top. This ground evidently could not carry a heavy embankment, and it could not be drained. I therefore, as a precautionary measure, had a wide trench cut down ten feet deep, under the toe of each slope, and the red marl from the adjoining Narroways Hill cutting then run into these trenches and the lower ten feet of the embankment to form a foundation for the upper forty feet, which was, two years later, tipped to the full height with lias clay, after the base of red marl had become well consolidated. We consequently had no slip there, although it may be judged what would have happened had these precautions not been taken, by the result in the case of the Clifton Extension line, which, a few years afterwards, was carried across the same valley two hundred yards lower down, causing great landslips on both sides. As also, in our case, we had to build a culvert and heavy road-bridge in the middle of the bank, which such slips would have utterly destroyed, the cure of the slips and the reconstruction of the bridge and the culvert would have been a very difficult matter, and might have involved the outlay of a sum to be reckoned by tens of thousands of pounds.

After crossing this valley the railway cuts slightly into the slope on the other side, where the Ashley Hill station now stands, and where an old natural, but rather superficial, landslip, at the back of the station building, gave a little trouble when the line was doubled, twenty years later. Above this station the railway again crosses the valley by an embankment 52 feet in height. A four-foot culvert had *first* to be put in under the deepest part of it to carry the brook, which is liable to sudden floods. When the contractor had got out the ground for the foundation of this culvert, the bottom was so bad that he did not know what to do. On inspection I found that the bottom was in lias slip-clay, in which the feet sank ankle-deep at every step; so I had a trial pit sunk near it, and found that the same stuff went down for 30 feet. The question was, How could a culvert be built upon that bottom to carry the load of a 52-ft. bank? I felt it to be a serious, momentous, and nervous question; for if that culvert should collapse after the bank had been made, it would of course be after heavy rains when it would be running nearly full of water. The heavy bank would follow the arch and choke the culvert. This big bank might in this way form a great dam across the valley, against which the water would rise, making a great reservoir of the valley above, until such time as it had accumulated sufficient force to cut itself a passage through the upper part of the bank. And this passage, though small at first, having once been made, it would very rapidly scour, until the water in a great body would burst through (as in the Holmfirth reservoir), and suddenly discharge a great flood, through the centre of Bristol, into the Floating Harbour!—for the brook runs into the Frome at Baptist Mills.

The facts to be considered were these: The valley bottom is narrow, and the sides rise, on either hand, at as steep a slope as the lias subsoil will allow. The railway crosses this valley very much askew, so that the culvert was a very long one, and had to be founded upon that soft slip-clay. But though the clay would *slip* in any available direction under such a load, I had ascertained that there was no *compressible* material, such as peat, mixed with it.

After thinking it over, I decided to build the culvert upon the bad bottom as it was, only covering it with a coating of lime and concrete, which enabled the men to stand upon it, and then to load the slip-clay *adjacent* to the culvert, so that this clay could not be shoved out laterally. For this latter purpose I had a little more land bought, and lengthened the culvert about thirty yards at each end. A very strong four-foot barrel culvert, 2 feet 6 inches thick, was then built, to the full length, of roughly dressed stones, most of which passed right through the work, and all set in good lias mortar.

The culvert was now nearly 140 yards long, and the whole breadth of the valley bottom from slope to slope, and for the 140 yards in length was then covered with a thickness of about four yards in depth of the lias clay from Ashley Hill cutting, making a sort of level platform across the bottom of the valley over which the bank, forty feet higher, might be tipped without fear later on, after this platform had become consolidated by two years' settlement. There still remained, however, another very weak place in this embankment. The forty feet of bank above the platform, before the level of the next cutting was attained, had to be made over slippery ground which, it had been proved, could not carry even five feet without slipping very badly. This I decided to remedy by efficient deep drainage; for that side of the valley had all the appearance of being an old natural landslip. A deep drain was therefore started from just above the level of the brook, at the upper end of the long culvert, and carried forward just inside the railway fencing, 2 feet 6 inches wide (just wide enough for the men to work in), and with upright sides supported by horizontal planks and short struts. When this drain had attained a depth of full forty feet, a copious spring of water was tapped. Two six-inch pipes were then laid all along the bottom of the drain, and it was filled up to the top with loose stones, the planks being withdrawn as the stones got up to them. Thus were completed the precautions against slipping in that embankment.

The next cutting was also in very treacherous and sideling ground, and with a high slope on the right-hand side. To drain this slope I had a *heading* driven under the railway fence on that side from end to end of the cutting, drain-pipes laid along the bottom, and the heading then filled up with loose stones.

Beyond this cutting there was a small embankment on very sideling ground, full of natural landslips and sloping down to the brook, which was close below. This was a very bad place; so a strip of land was bought on the other side of the brook, a culvert 60 yards long put in to carry its waters, and the railway embankment slope carried well over the culvert, so as to obtain a good footing on the other side. From this point the railway runs along the sideling ground for 12 or 15 chains, with embankment only on the left-hand side; and this sideling ground is apparently covered with natural landslips. Along this part I had a trench cut 14 feet deep, drain-pipes put in the bottom, and the trench then filled with stone as before. This last length was the only part as to which I had any doubt, fearing that the old natural slips might be too deep-seated for my remedy to be fully effective, with the brook so near below.

The railway has now been opened for nearly thirty years, and there has been no sign of a slip upon it anywhere; but the Permanent-way Inspector recently told me he had observed that the lines of rails had, along that last length, drawn perceptibly towards the brook. There is, however, a certain remedy for this, applicable at any time.

Other slips I have had, which were always cured by the use of stone counterforts or by thorough drainage; but, as there was nothing remarkable in them, they do not call for notice here. I may now proceed, therefore, to allude to a few of the *natural* landslips which I have visited.

Natural landslips are commonly on a very large scale. There are many noteworthy ones round about Abergavenny; and as the geological formation there is the old red sandstone and marls, which are not readily caused to slip, the appearance of these slips is all the more characteristic and picturesque. They are to be found only on the steep mountain side, where a spring of water comes out upon a bit of marl which has to carry an enormous superimposed mass of rock. A characteristic example of this sort of slip may be seen high up on the south aspect of the Crickhowel mountain. It is well shown on the old, inch, Ordnance Map. The slip is about a quarter of a mile wide, and has gone down many hundred feet—the rock riding upon the top having been broken up into fragments and scattered in ruinous masses far down below. Such a slip as this, as everything belonging to it indicates, must have come down at once and for good—there is nothing now left to slip any further. The Welsh name for them is "Daren," which means "noise;" and no doubt such a slip did make some noise when it fell. There are some other *darens* at the south end of the Black Mountain range; but the most remarkable slips I have seen are those of the Skirrid Vawr, a mountain about four miles to the north-east of Abergavenny, and in the same old red sandstone formation.

The Skirrid Vawr is an abrupt and solitary mountain, of which the top, about a mile in length, and running nearly north and south, is yet as narrow as the ridge of a steep roof, but rising gradually from the south end to the northern summit.

At the south end and all along the western flank there are a series of great landslips. The top, being for many feet in depth formed of strong beds of old red sandstone, has ridden down upon these slips, and forms peculiar and sometimes picturesque knolls of rocky material, with a narrow gorge of more or less depth between it and the rocky face from which it broke away; but the most remarkable slip is a great one at the north end of the western slope. This slip parted from a little below the summit on that side, leaving a vertical cliff, and the part that broke off has moved down, leaving a deep gorge about 500 feet wide, with a high cliff at the top on the other side, the summit of which is about 200 feet lower than the cliff from which it broke away. There it has stood no doubt for a long time; but the movements of this slip must have been smooth and equable, in order to have left the lower cliff so little disturbed.

From the direction of Hereford, nearly due north, this landslip has given a peculiar appearance to the mountain, making it look as if it had been cleft in two; and, from this appearance, some superstitious people have named it "The Holy Mountain," professing to believe that it was one of those that were *rent* at the time of the Crucifixion. The old red marl is, however, a most unsuitable material for keeping up the *continuous* movement of a landslip; such slips usually, therefore, come to rest again quickly. Hence result those peculiar knolls and rugged forms.

SLIP OF THE ROSSBERG.—In travelling on the Continent, I have observed some natural landslips on a much larger scale. The most remarkable among those that I visited was a comparatively recent one of the Rossberg mountain at Goldau, near the lake of Zug. This slip took place in 1806, and buried the greater part of two villages, with their 120 inhabitants, during the dinner hour.

The Rossberg is a mountain of nearly 5,000 feet elevation, and taking that of the valley at 1,800 feet, this leaves the height above the valley of some 3,000 feet; and as the distance is about 8,000 feet, the slip gradient would be fully 1 in 3.

When I visited the place in 1857, I was greatly struck by the enormous heap of rocks and rubbish lying in the valley below. The masses of rock, many as big as a cottage, were thrown into all sorts of fantastic attitudes, and the force and velocity which the mass had acquired was evidenced by the slip rubbish having travelled quite across the valley, a mile and a half wide, and some distance up the opposite slope, some very large blocks having gone a good many feet up the steep slope of the opposite mountain. The *débris*, which covered more than a mile in width of the valley, lay, it was said, 100 feet deep above it and the buried houses, and had filled up one end of a small lake named the Schwanau See. It was a scene of marvellous devastation when I saw it.

After scrambling some way up the slip, the cause of it was obvious. The dip of the strata was about parallel with the general slope of the mountain, something like 3 to 1—quite a climb, in fact. The slipping surface was formed by a bed of pale-coloured clay, having a stream of water over it. Standing on this bed of clay and looking round, there were the walls of the slip quite 300 feet high, it seemed to me, and vertical. It looked as if there had been two nearly parallel vertical fissures through the rock, passing right up the mountain slope, perhaps 400 yards apart where I stood; and that this mass of rock had suddenly lost its hold upon the two sides and slid down, upon this bed of moistened clay, for the whole height of the mountain side, thundering into the ill-fated valley below like the shock of an earthquake. The walls of rock were composed of strong beds of great thickness, thirty or forty feet it appeared to me and as was fully borne out by the great size of the broken blocks standing up in fantastic attitudes amongst the *débris* below, some lying prone and some tilted up against one another in endless confusion.

I have said that the dip of the strata was about parallel with the *general* slope of the mountain side; but, towards the bottom, the superincumbent beds of rock lying upon the clay had, at some former geologic time, been greatly scoured away, so as to leave there a comparatively thin and weak buttress to support the enormous load above; thus, when this at last gave way after heavy rains, the whole mass suddenly came down together like an avalanche.

The slip came down in the middle of the day, while many were having their mid-day meal; and some few, who were gone to a neighbouring town to market, had a remarkable escape from the general destruction.

But a peculiar incident occurred in the Schwanau See lake. This lake is now about two miles long by three-quarters wide, and in its middle there is a little island. On this island in 1806 there stood a small wooden chapel, with its paintings, images, and relics inside, and also a priest to look after it and welcome the numerous visitors who, as the fashion then was, came over in boats to visit it and leave their offerings. When the slip came down at mid-day it suddenly filled up a half-mile of the then lake, and this sudden displacement of water raised an immense wave (I suppose newspaper writers would call it a *tidal* wave, because it had nothing to do with tides, like all those to which they give that name), and this wave rushed along the lake, passed over the island, bore off the wooden chapel, with the priest inside, and broke, as an enormous breaker, upon the shore at the other end, landing the little wooden chapel high and dry more than 100 yards inshore. It is said that the priest was frightened, but not hurt.

SAINT GOTHARD.—I may now conclude by some remarks upon the St. Gothard Railway, which I visited in September, 1882, shortly after it had been opened.

Starting from Lucerne, the railway runs up the valley of the river Reuss. The day was fine, and in the bright sunshine the scenery, as we ascended the valley, was most charming. In the upper parts this river becomes an impetuous mountain torrent, the clear, pale-green waters dashing round the enormous granite blocks with great force, and fifty feet below the narrow strip of bright-green alluvium which capped these rocks, with here and there a picturesque pine or group of pines. All these in the bright sunshine formed a most beautiful panorama as we puffed up the gradient.

But the most remarkable thing there was, perhaps, the railway itself; for at one spot, on looking ahead out of the window, we could see, upon one shoulder of the mountain, three distinct lines of railway rounding it, each 200 feet or so above the other. Nobody could have believed that all these were portions of one and the same railway; but they were. The fact is that, in ascending the valley, the river gradient becomes much too steep for that of the railway, and the engineer, consequently, in order to obtain his gradient, has made a full circle of tunnel into the solid rock of the mountain, like one turn of a corkscrew, and come out again at a considerably higher level, according to his gradient. There are, I believe, two or three of these corkscrew tunnels on this incline, and this accounts for the peculiar appearance I have mentioned.

The St. Gothard tunnel was arched for a double line, but excavated only for a single line, on the eastern side of it.

In descending the valley of the Ticino, on the Italian side, the scenery appeared even more lovely than that up the Reuss, and very full of interest to an engineer. It was perfectly plain to see the course taken by the mountain torrents during wet seasons, in their plunging descent down the abrupt mountain slopes on either side; and it was interesting to notice the great spans of the archways provided for the passage of their waters, where no water was visible at the time. But during wet times great streams of water must come down these courses, and it was plain to see the spots where grand waterfalls must pour over the cliffs at such times.

Here and there occasionally could be seen places where avalanches of snow must have come down, clearing away all trees or other obstacles in their course. These were provided for on the railway by making short tunnels for them to pass over without injury to the line.

Lastly, there were numerous places where might be noticed characteristic rounded, and more or less steep banks of rubbish and of slip-earth, a sort of *talus* which had come down from the mountain sides into the valley, and had there accumulated at an extreme angle of slope. The railway was cut through these in deep cuttings, or occasionally passed through in tunnel. They caught my eye immediately, and I noted—Here was trouble to come!

The train stopped at Airolo, and as the valley was so beautiful I spent the night there; and having a letter of introduction to the local engineer, we walked back along the line to the tunnel mouth. I then observed that the slopes of these deep cuttings through the taluses already mentioned were already treacherous, and that the engineers, as a precaution, had carefully staked and planted them—a merely superficial operation, of little use.

Passing on to Milan, I was greatly struck by the splendid public Acclimatisation Gardens, and by the first view of the magnificent cathedral, with its thousand pinnacles. Built entirely of white marble, its exterior is very striking; but on going inside I did not like it. There is a want of equilibration in the entire structure, and the upper portion has had to be tied together by great iron tie-rods from pillar-top to pillar-top, and on to the springing of the arches on the top of the walls.

Returning to Bellagio, the most beautiful spot on the most beautiful lake of Como, I watched a thunderstorm as it passed grandly over the lake and the riparian mountains. A succeeding storm drove me back to the hotel. A third thundered over us while at dinner; and during the night a terrific thunderstorm, with furious wind and hail, passed over. The combination of noises was extraordinary: that of the waves breaking upon the rocks at the foot of the hotel, the continual rushing of the hailstones, the howling of the wind, and the constant slamming of an outside jalousie shutter against the window, together with the continual heavy peals of thunder, kept every one wide awake; and when we got up in the morning the hail was piled in heaps several feet deep around the hotel, and the upper two-thirds of the mountains bordering the lake were covered with snow. From being hot summer the day before, it was now winter. The landlord of the hotel was in terrible distress at the prospect of losing all his visitors so early in the season; and I made up my mind to return home at once, before anything should happen to block the railway. And well it was I did so. When I got to Airolo there were nine inches of sloppy snow on the ground, and thick, half-melted snow was falling all the time. As I passed along I could see the raging torrents rushing down the, what had been, dry channels, and some grand waterfalls, as I had anticipated; but the view of them was greatly obscured by the constant fall of snow. I went straight home, and soon after I got there I read of great *landslips* that had taken place and blocked the railway. The heavy rains kept on for a fortnight continuously, and caused the collapse of one of the tunnels that had been made through the foot of a talus, and great damage was also done amongst the mountain villages round about by landslips. All this occurred at a time of year when there is usually beautiful summer weather.

Some of the Water-Bearing Strata and Wells sunk in same,

With special reference to Wells in the New Red Sandstone Formation.

By HENRY WILLIAM PEARSON, M.I.C.E.

IN selecting this subject for a paper, I have been led to give it this title, and also to treat somewhat upon rainfall, as the two are so intimately allied that it would be difficult to describe the sinking of wells through any strata without at once associating them with the rainfall.

If it should appear, therefore, that the subject has been too lengthily gone into, I trust it will not prove tedious.

The practice of well-sinking is of very early origin, and we have records in Scripture of the wells in the plains of Syria and in Egypt, which doubtless were excavations of no great depth into the sides of rocks, from which the water was raised by hand buckets.

Boring for water is also of very ancient origin, and there are described records of its existence in Egypt. Mons. Dejousée, a French engineer, mentions, in his *Guide du Sondeur*, that he delivered to the Pacha of Egypt machinery for opening wells of probably 4,000 years' existence.

In China, too, the practice of boring has long been known, and many thousands of wells and borings have been constructed to depths of from 1,500 to 3,000 feet, of five and six inches diameter.

These are formed by using a "trepan," or "bit," through a wooden tube sunk into the surface of the ground for a few feet, through which the trepan (fastened at one end of a lever to a cord of ratan), weighing three or four cwt., was worked, a man at the other end of lever raising and depressing it, and so jumping the hole through the strata, a circular movement being given to cause it to take a different turn at each drop by a cross arm of wood. These are said to have cost a "tael" a foot; a "tael" is equal to 6*s.* 3*d.*

In France the art of boring was early known, notably in the province of Artois, from whence the well-known term of Artesian well boring takes its name. One of the earliest of these wells was executed at Lillers, in the Artois, in 1126.

In our own country the first recorded instance of boring by this method is when Sir C. Wren adopted it to ascertain the nature of the strata under the foundation of St. Paul's; and in the latter part of the 18th century such borings were made in Great Britain in the wolds near Louth in Lincolnshire, and in the London basin near Tottenham.

To leave original practice, and turn to that of our own day, I will confine myself to wells and borings in the Chalk and New Red Sandstone, with which I am more familiar, although there are other measures where water is abundantly found; for instance, in the Pennant Grit between the Upper and Lower Coal-measures, the Millstone Grit and Old Red Sandstone.

Before going on to the actual description of the work of sinking and boring, it would be well to glance at the particulars of the rainfall, the source of the water supply, not only of wells, but of rivers, and brooks, and surface springs.

The average rainfall of England and Wales has been ascertained, from the mean of a variety of experiments, to be equal to three feet of water, supposing this to accumulate on the surface of the ground, allowing nothing for evaporation and nothing for soaking in.

Now from thirty to forty per cent., or somewhat more than one-third, of the rainfall is found to percolate through the strata to go to wells and springs, the remainder being left to shed off and to evaporate.

The surface of England and Wales is equal to 58,320 square miles, and taking one-third of the three feet, or one foot, we get a quantity of water sinking into the bowels of the earth equal to sixteen hundred and twenty-five thousand eight hundred and sixty-eight million two hundred and eighty-eight thousand cube feet, or 10,161,682,800,000 gallons. To be able to grasp this quantity better, I have compared it to the Vyrnwy Lake, just completed, for supplying Liverpool (which contains 13,300,000,000 gallons), this vast subterranean reservoir being therefore nearly eight hundred times larger than that lake.

It must be borne in mind that the percolation taken is the average percolation over the area of England and Wales. This varies somewhat according to the latitude and longitude or geographical position of the area, viz., in England, whether it is in the north, south, east, or west, or geologically, whether in Chalk, Sandstone, Pennant, Millstone Grit, or otherwise, and according to the changes of temperature due to the periods of the year, which necessarily results in more or less evaporation.

The average rainfall on the Mendip Hills is equal to forty-four inches; out of this an allowance for evaporation (if calculated for yield) would have to be made of fifteen to sixteen inches.

In the sandstones, with which I am more conversant, in the area west of Bristol, at Chelvey and the neighbourhood adjoining Nailsea, I should allow from experience a percolation of from forty-five to fifty per cent. In making this estimate I have regard to the level at which the country lies, and to the fact that the streams have not their origin from natural spring heads, but are produced by the overflowings of waterlogged strata issuing in the form of bottom springs in the river bed.

In the watershed and valley of the Frome, the waterlogging of the Pennant Grit and Upper Coal-measures and surrounding sandstone gives a very large percentage of percolation equal to fifty per cent., which results during heavy rainfalls in the water shedding off almost bodily into the Frome, and so producing disastrous floods.

The Pennant Grit between the Upper and Lower Coal-measures in the Nailsea basin, nine miles west of Bristol, is a good illustration of the water-yielding properties of this formation, where it has a thickness of about three hundred feet, and yields from five to five and a half million gallons per day.

In chalk, which is more compact, from fifteen to twenty-five per cent. only percolates, and in the county of Hertfordshire, from the New River Company's sources, it is estimated that the natural percolation amounts to four inches out of twenty-six inches of rainfall ; but pumping opens the horizontal apertures in the chalk, owing to carbonate of lime being dissolved and carried away by the water with the action of pumping.

The cycle of climate in England over which a series of gaugings should be taken is about seventeen years, during which time wet and dry years will occur, and also excessively dry years, in which the rainfall is small, and consecutive dry years occur, which affects the percolation of water, and is the measure of the yield which can be relied upon in wells.

We have had instances of such years, in 1864 and 1887, when the rainfall was thirty-three per cent. below the average. In the current year, up to the present it is equal to only twenty-nine inches, or nearly twenty-five per cent. below the average.

Well-sinking Sites.—In sinking wells for large water supplies it is of course necessary to select the site which will be most likely to prove favourable to a good yield, and this entails a certain amount of geological knowledge to ensure the success which should attend the operation; for, although it is pretty generally known in what strata the well should be sunk, it does not always follow that the position of such strata is favourably situated for obtaining water.

For instance, we should not select the lias formation capping the top of a Carboniferous Limestone hill, where there would be little or no watershed, unless we knew of the existence of water under such strata, indicated by springs, which would most probably arise from some other formation (say New Red Sandstone), from which water was thrown up by the superimposed clay. Nor should we search in New Red Sandstone where its elevation was considerably above the sea level, and on the crest or flank of a hill with a sharp inclination towards a valley drained by natural springs and rivers. Nor again should we seek water in a compact mass of Mountain or Carboniferous Limestone, which is generally of immense thickness (2,000 feet or more in the Bristol district), and sheds water through large open joints and fissures at a high angle to any depth, although huge quantities of water are stored up in the large caverns so frequently met with in the Mountain Limestone, notably at Cheddar, and in the sinking of the Severn tunnel shaft at Sudbrook, which drew the water from a large tract of Mountain Limestone district between there and Wentwood.

These Limestone areas generally store their water in this manner, which finds its way out through "swallets," or underground channels, or gushes out in large volumes (where it is thrown out by faults, or upthrows, or other dislocations), like the springs at Cheddar and also on the north side of the Mendips at Rickford, near Blagdon (eleven miles south-west of Bristol), where it flows out of the chasm in the almost perpendicular side of the limestone, at the rate of three or four million gallons per day, increasing very quickly and copiously after heavy rainfall.

Again, at Banwell we have another instance of the outlet or final appearance of one of these swallets, or underground rivers, draining the Mountain Limestone area on the southern and western side of the Mendip range, yielding from three to eight million gallons per day in the driest summer; the pond at Banwell, which covers about one and a half acres, and is from three to five feet deep, filling in two hours.

The Chalk Formation.—The chalk formation which surrounds London, stretching southwards to Hampshire, Kent, and Sussex, and eastwards taking in a great part of Hertfordshire and the whole of Norfolk and nearly all Suffolk, as well as part of the north-east of Lincolnshire and Yorkshire, is a very fruitful source of water supply. It covers an area of 26,600 square miles in England, of which 19,000 square miles are overlaid by impermeable strata, such as clay.

Wells are sunk into this formation in the London basin and district adjoining, around Newbury, Wokingham, Leatherhead, and Rickmansworth, and on the outcrop of the chalk of the London formation, and also at Southampton and Portsmouth and numerous other places.

The London clay superimposing the chalk renders it more dense than it would otherwise be, where it is without such weight, and would consequently leave a freer passage for water through its interstices, owing to its having a line of least resistance, and a well sunk in such chalk would deliver water more freely than the other.

Wells sunk in chalk always get a free supply of water from the Upper Flint Beds, where the underground spring water is flowing to some natural outlet, say a river or spring; and as sinking is continued, the water has a very slow movement through the horizontal fissures, and comes up milky; but as before mentioned these fissures are opened by pumping, and a freer circulation and issue is set up.

Around London and at Wokingham, the wells are sunk to a depth of from 300 to 400 feet, the chalk bed being about 650 feet in thickness.

The wells at Trafalgar Square are 395 feet into the chalk, yielding 500,000 gallons per day.

The New River Company, London, pump very largely from the chalk, as also do the Kent Waterworks Co. (the latter entirely) from wells at Deptford, Woolwich, Chiselhurst, Crayford, and Dover Road.

The New River Company have numerous wells between London, viz., at Amwell Road and Amwell Hill, and along the line of the New River into Hertfordshire, *via* Broxbourne and Hoddesden.

The water from these wells is for the most part delivered into the New River, close to which they are situated. This forms an open conduit terminating at the Company's station at New River Head in storage ponds, the site of the original works formed by Sir Hugh Myddleton 280 years ago.

This Company delivers into their district from these wells and the Lea River an average daily supply of thirty million gallons, and the Kent Company seven to eight millions.

The chalk wells and springs singly yield from a minimum of six to a maximum of five hundred cube feet per minute, equal to 4½ million gallons per day.

Pumping in the chalk around London has had the effect of permanently depressing the level of water, as evidenced by the sudden lowering of the water from an inclination of from ten to fourteen feet a mile, to a sudden depression of from twenty to thirty feet a mile at Kilburn.

In the Kent district the inclination is about forty-seven feet in a mile; while between Dunstable and Hertford the inclination is again fourteen feet a mile.

Chalk absorbs water to a large extent in saturation in its pores, viz., about one-third of its bulk, that is, a cube foot of chalk will hold just over two gallons, and parts with it very slowly; the springs met with in sinking, it must be borne in mind, being mainly due to free water passing along the cracks and fissures which traverse it in all directions down to its lowest portion.

Before leaving the question of chalk wells, a description of two bored at Southampton may be interesting.

Trial bore-holes sunk to prove the formation yielding very good results as to speed of work and quantity of water, it was determined to sink with chisels two 6-ft. wells, 11½ feet apart, centre to centre, instead of one of large diameter.

The excavations for the engine-house over the wells was made to the required depth, and at the bottom of these two cast-iron cylinders, 6 ft. 6 in. diameter, were placed to form entrances to the wells.

A staging was erected above the water level, and from this the work proceeded, the boring tools being lowered by means of a 2-in. cable wound round a double purchase steam winch, so that it tightened when the boring tools were raised and slacked when they were dropped, thus giving the necessary jumping motion to penetrate the strata.

The *débris* was afterwards raised by a miser weighing $1\frac{1}{4}$ tons, with flap valves above which the *débris* was forced, and so drawn up to the surface.

The depth of the wells was 100 feet, costing £5 14*s.* 6*d.* per foot for each well.

The chalk being of a friable nature, it was found necessary to line them with tubes of mild steel, 1 inch less in diameter than the wells, and $\frac{1}{2}$ inch thick.

These were made in 6-ft. lengths in two segments, with butt joints, and inside covering strips and flush outside; holes were left in the plates at side to allow of free ingress of water.

The tubes were lowered into place by their own weight, and the cost of lining was £780. The total cost of the bored wells was £1,700; one of equal area sunk in the ordinary way would have cost £2,500.

The hardness of the waters in the chalk is 16° to 18°, mostly temporary.

New Red Sandstone Wells.—The New Red Sandstone formation both in the Keuper and Bunter series is always looked upon as an area which can be relied upon for yielding supplies of water of abundant and good quality.

I do not know that any computation of the area has been made, but taking it approximately from the Geological Map of England and Wales, it covers an area of about 12,000 square miles, chiefly in England, and situated mostly in the Midland, North Western, and Western Counties; and if that covered by the Lias (which the Sandstone possibly underlies to a large extent) be taken into account, the area would be increased by 6,000 square miles.

The New Red Marls and Sandstones of the Keuper are geologically situated in the Trias formation, and immediately under the Lias and Rhœtic or Penarth beds.

The Keuper Marls come first in order, the name being of German origin. They consist of either soft white or grey sandstones, and red and variegated marls, with gypsum more or less thinly bedded, and in the Bristol district are underlain by the Dolomitic Conglomerate, a water-tight rock, which is the salvation of the coalpits which it overlies, being called by the miners the water-tight overlie.

The series immediately under the Keuper is the Bunter, consisting of red and variegated marls and Bunter Sandstone. This division of the Trias is absent in the Bristol District.

It is from these sandstones (the Keuper and Bunter) that some of the largest cities in England are supplied, notably Birmingham, Liverpool, Wolverhampton, Nottingham, Lichfield, and South Staffordshire.

In Liverpool there are seven wells averaging to the bottom of the bore-holes (of 6 inches to 8 inches diameter) from 245 to 369 feet below mean sea level, these wells being (most of them) sunk within the city boundary, and the eastern area being a bare drift of boulder clay giving high evaporation, a low percolation of not more than from twenty to thirty per cent. of the rainfall is the result.

The yield of these wells gave an average daily quantity for ten years, ending 1876, of seven to eight million gallons per day.

The supply is now augmented by the Vyrnwy Lake just finished, situated on the Lower Silurian Rock (with a drainage area of 34 square miles, or 22,000 acres, over which the rainfall is estimated at 70 inches per annum), at a cost of two millions sterling, but not yet brought into use owing to the stoppage of the tunnel under the Mersey at Fidler's Ferry, on account of difficulties met with by the contractor in a shifting sand when excavating.

The supply averages from sixteen to eighteen million gallons per day to a population of from 650,000 to 700,000.

At Birmingham the wells in the New Red Sandstone vary from 130 feet to 400 feet in depth, supplying a population of 450,000 to 500,000 from wells at Aston, Perry Well, and King's Vale Wells, yielding 10,000,000 gallons per day.

At Wolverhampton the supply is from wells in the New Red Sandstone and from the river Worf, a tributary of the Severn.

At Nottingham the supply is from wells in the New Red Sandstone at Basford and Bestwood, sunk to an average depth of 190 feet, yielding three million gallons per day.

Turning now to the West of England, the localities in this stratification with which I am more familiar are those situated about nine miles to the west of Bristol, viz., at Chelvey, near Yatton, and to the south-west in the valley of the Yeo, twelve miles from the centre of this city.

The rainfall in these districts averages from 31 to 42 inches per annum; of this, not less than from 14 to 16 inches percolate into the sandstone.

The chemical constituents of this sandstone are silica, alumina, magnesia, lime, and iron.

The sandstone takes up or absorbs about one-fifth of its weight of water, or nearly one gallon per cube foot, especially if of an open nature.

The quantity which will pass through a square foot of from 10 to 12 inches thick varies with the head. Thus at 23 feet, $4\frac{1}{2}$ gallons; at 56 feet, $7\frac{1}{2}$ gallons; at 105 feet, 19 gallons; the increase being directly as the pressure.

I should take in this district an annual percolation of 16 inches of rainfall, equal to 700,000 gallons per square mile, as it is very heavily saturated, and the surface stands only

50 feet above mean sea level, with an absence of any streams having their origin from head springs.

I estimate the area contributing to the yield of water from these wells as equal to 8½ square miles, which gives a quantity of nearly 6½ million gallons per day, which is borne out by the amount of pumping which has to be resorted to as far as the area acted upon by the cone of exhaustion has been developed.

The form of well which lends itself to the least labour and expense is undoubtedly the circular form, but it is not always adaptable to the pumping plant required to be placed in it.

The well the sinking of which I am about to describe is one of a series sunk at Chelvey, and is of a circular form.

This well is 7 feet diameter, and 160 feet in depth; for the first eighteen feet of its depth it was sunk through the red marls, a small quantity of water being met with.

The sinking then went on at the rate of 10 feet per week down to a depth of 67 feet, when the water proving too much for the small pump in use, a 10-in. pump (fixed from timbers near the top of the well) was brought into use, driven by a 12 horse-power horizontal engine. The sinking was then stopped for a few months, and when again renewed, a cast-iron curb was put in, and 9-in. walling to break joint brought up to the surface from the curb.

These curbs were nogged into or set back in the marl, upon a benching, in segments, with internal flanges, having lips forming a trough standing out beyond the face of the steining about 3 inches, for the purpose of catching the water, so that it could be conducted to the bottom of the sinking by wooden and canvas shoots to the suction of the pump.

The sinking was then proceeded with to a depth of 72 feet, when it was suddenly interrupted by the tapping of a strong volume of water equal to 300 gallons per minute, under a bed of hard stone, severely taxing the pump.

This water had now to be dealt with, and it was clearly seen that if the sinking proceeded, with this water coming in, the pump would be overpowered; it was therefore determined to wall this water back.

Before doing this the sinking was further carried down 8 or 10 feet, so as to get well below the water-bearing strata; and to protect the sinkers and enable the work to proceed, shields of wrought-iron plate, $\frac{1}{8}$-in. thick, were depended and fastened from the curb above, the water being conducted down from behind these shields with temporary bratticing cloths and wooden garlands to the pump suctions, which were made sliding to enable them to be easily accommodated to the gradually increasing depths.

In this manner the water was conducted down until the fissures through which it issued were passed, this occupying a little over a month, or at the rate of about 2 feet 6 inches a week.

Another permanent cast-iron curb was now fixed in the manner before described, and from this curb 18 inches of brickwork in cement was raised, the iron shielding being brought down to it, and so allowing the brickwork to be brought up fairly dry, spaces being left at the foot of this section to allow the water to flow to the pump from the back of the wrought-iron shields. As the cement lining was raised, it was allowed time to set, and at intervals cocks fitted into cast-iron boxes built in the brickwork were inserted into spaces behind the walling, from which shoots or piping were carried, which were kept open as the brickwork was raised to allow the water free egress.

In this manner a tight walling was obtained, care being taken to bring up at the back of the walling pipes of lead, to allow of the escape of air, penned in by the water. When the cocks were finally closed and the masonry had set, these were, after a few days, hammered up, it being previously ascertained that all the air was out.

The sinking was again proceeded with, the work of pumping being reduced from about nineteen strokes per minute to three or four.

A depth of 100 feet was reached in March, 1872, or a little over four weeks (being at the rate of about 5 feet a week), when the strata reached showed itself to be more of a sandy nature and with more water, and it was therefore deemed advisable to fix extra pumping power, and pumps of 14 inches diameter, with a 5-ft. stroke, were decided upon, and one fixed in addition to the 10-in. pump already at work. The arrangement of fixing this pump was by securing it by the flanges upon transomes or cross timbers fixed at intervals in the well (provision was also made for the second 14-in. pump when necessity arose), strutting pieces being put under the flanges to accommodate the different levels to which they might come in lowering the pumps down.

A gantry was also fixed over the well for lowering the pumps and putting in extra rising pieces as the sinking proceeded.

An engine-house was erected for working this pump, in which a 20-in. cylinder horizontal engine of 4-ft. stroke was erected. I may here mention this method of fixing pumps has since been superseded by hanging them in sling rods from the surface, so that they are able to be raised or lowered without employing a diver, which had to be done (owing to the pumps not being able to cope with the water) when any alterations were required.

At a depth of 120 feet a further yield of water was obtained in the sandstone, in pebble pockets and beds, necessitating the lowering into the shaft of the second 14-in. pump in place of the 10-in. pump, which had to be removed, the clack seat having burst through too fast driving.

Sinking now went on at the rate of 2 feet per week, with a quantity of water to be pumped of 500 gallons per minute, the strata passed through being variegated sandstone and a grey stone in beds of from 9 to 18 inches thick, giving out water.

I may here mention (to show the large amount of water held in this area) that a small well only 80 feet distant, with bore-holes to a depth of 140 feet, was overflowing the surface of the ground at the rate of 190 to 200 gallons per minute at the same time as the sinking was going on in this well.

Another stage of sinking to a depth of 142 feet was reached, at which depth further yields of water were met with in the pebbly joints before mentioned, these pebbles being quite loose in the fissures, which were large enough to allow of the hand and wrist being inserted, and had evidently been rolled about by the action of the water in its passage through the joints of the sandstone.

It was here decided to sink the well to a depth of 160 feet, with a view of driving headings at a depth of 140 feet.

To prove the ground a 4-in. bore-hole was put down, and at a depth of 177 to 180 feet a spring of 200 gallons per minute was tapped.

The sinking to the stage of 160 feet proved to be slow, on account of the difficulty experienced in coping with the water, taking six months to accomplish the depth of 20 feet, the buckets and valves of the pumps having to be constantly withdrawn for examination, for if the least worn the pumps were overpowered.

The quantity pumped at the termination of the sinking was equal to 1½ million gallons a day.

Some Observations on British Mice.

By H. PERCY LEONARD.

IT is quite possible for an expert field naturalist, whose studies lie in other directions, to be almost a stranger to the sight of a wild mouse. The nocturnal habits of some, the extreme quickness of movement in others, their retiring dispositions, and their insignificant size, all combine to make them unnoticed. The word mouse is said to be derived from the Greek μυειν, to hide; and if so, then it may truly be said that they deserve the name.

Of course the most familiar of these creatures is the common house-mouse (*mus musculus*), whose activities in the larder make him detested by the careful housewife, but whose lively disposition and interesting habits go far towards reconciling the naturalist to that isolation from nature which town life necessitates.

The house-mouse is widely spread; it has been found in China by the Amoor River, and Darwin mentions it as a resident of the island of Ascension.

This animal is too well known to need any description. It is well fitted for its life behind the wainscot, for though in total darkness it feels its way by means of its spreading whiskers, the ears also are well supplied with nerves, and are used as organs of touch. From long contact with man, a most insidious foe, it has developed an amazing sagacity. It soon becomes wary of traps, and after a short run of success the most tempting bait will fail to entice to destruction, and the trap must be laid aside until a new generation shall have arisen, when a few more may be caught; the rest taking warning will shun the danger, and the trap once more becomes useless.

I have read in a book of anecdotes the fact that mice have the cunning to sham dead when suddenly surprised and escape is impossible. An instance of this supposed cunning came under my notice; the occasion was as follows. I entered an outhouse suddenly one evening with a candle in my hand, and as I was leaving my attention was attracted by a mouse clinging to the stone wall. I took it up, but it seemed very lethargic and almost unconscious; as I stroked it, it recovered its activity, and ran up and down my coat-sleeve, and finally sprang to the ground and disappeared. It had all the appearance of a paralysis of the whole system produced by fright.

My experience goes to show that there is a great preponderance of males over those of the gentler sex. I once caught twenty-eight mice in a trap, and found to my surprise that they were all males. It may of course be urged that the superior feminine intelligence avoided the snare which deceived the obtuse male understanding; but the fact remains. We must therefore suppose great difficulty in obtaining mates, and this should make us incline to leniency, when our slumbers are broken by scuffling and squeaking in the walls; let us remember that unless a mouse is prepared to fight valiantly he must remain a bachelor. "Faint heart never won fair lady," is pre-eminently true in mouse society.

The size of the adult house-mouse is larger than is commonly supposed; it is only the young ones that are caught as a rule, because the more mature specimens have the cunning to avoid the danger. The elders, too, are more chary of showing themselves; but the youngsters will sometimes appear in public in the most incautious fashion.

The long-tailed field-mouse (*mus sylvaticus*) is perhaps the most handsome of our British mice. The colour of his fur is a rich reddish brown on the back, and a pure white underneath; his ears are large and outstanding, and his eyes are very prominent, and exactly resemble black glass beads. This mouse is to be found in all situations—on commons, in the woods, by the streams, and in the hedgerows.

He has an abiding place in our literature, for has he not been immortalised by Burns in his pathetic lines beginning, "Wee, sleekit, cow'rin', tim'rous beastie"? He is also the hero of those familiar verses of the nursery, "Do you know the little wood-mouse, that pretty little thing?" This poem gives a good idea of the habits of the animal, but makes an error when it asserts the fact of its hibernation, thus confounding it with the dormouse.

This mouse makes a very interesting pet. One afternoon in late autumn I went into the country, with the fixed intention of bringing home a wood-mouse, but not until the shades of evening began to close did I meet with any success. I was about to return disappointed, when I noticed a wren's nest on the top of an ivy-covered hawthorn bush about five feet from the ground. Putting my fingers into the nest, I surprised a wood-mouse, who promptly ran out, and tried to escape by running down the trunk, but finding himself intercepted he was obliged to remain on the bush. After a long and tedious pursuit, he sat resting quietly in the ivy by the wren's nest. I saw my chance, and quickly seizing his tail, I secured him, and safely imprisoned him in a little box I had with me.

This was the beginning of an acquaintance which soon ripened into intimacy. He became very tame, but not before he had bitten me pretty severely once or twice. He would sit with perfect confidence in my hand and eat his bread or cake, or ramble at will over the seats of the chairs, picking up the crumbs that had lodged in the folds of the upholstery. I kept him in a large open wooden box, in one corner of which I formed a small mound of moist earth. In a very short time he had made himself a burrow. I could see him at work, and noticed that he used his teeth for excavating, his paws being only used to throw out the *débris* behind him. Every now and again he would emerge and shake off the fine earth adhering to his fur, as a dog shakes off water; then he would sit on his hind legs and perform a general toilette in the manner of a cat, and then down he would go and set to work again.

He was a very audacious little creature, and it was an amusing sight to watch his behaviour toward a guinea-pig. The two combatants were put upon a large table, and the guinea-pig, in that blundering, shortsighted fashion of theirs, would approach the mouse, sniffing audibly. The mouse, not in the least cowed by his antagonist's superior size, would stand on his hind legs and deliver one or two stinging blows with his fore paws to such purpose that the inquisitive cavy was forced to retreat.

In the following spring I took him back to his home by the hawthorn. He darted hither and thither, and seemed to recognise the old landmarks with great satisfaction. I tried to catch him, but he kept his distance and in a short time disappeared from view.

The long-tailed field-mouse has the provident habits of the squirrel, and when autumn showers down her lavish gifts, he collects and stores great quantities of food for his use during the winter months. In chambers underground and in hollow trees he will conceal considerable quantities of acorns, nuts, corn seeds, and certain kinds of roots. One of these underground store-rooms, when opened, was found to contain a gallon of nuts, which represents a great deal of hard labour, considering the size of the gatherer. It is these subterranean hoards which form one of the main inducements to hogs to grub up the ground; and if every now and again they light upon a gallon or two of acorns, we can well imagine that it is a profitable occupation.

I once found an old felt hat in a clump of bushes, the folds of which were tightly packed with hips, gathered from a dog-rose close at hand; it was evidently the work of a mouse, because the marks of his teeth were visible upon the rind of each berry.

Walking in the woods near Clovelly one rainy day with two companions, one of these mice was pointed out to me, running in the roadway in front of us. Hearing our approach, he at once turned and took shelter in the ferns by the roadside. We stopped perfectly still, and in a moment or two he reappeared. He seemed to have no fear, but walked up to us, and presently climbed upon my foot and saucily nibbled the boot-lace. We offered him chocolate, which he refused, and soon after made a leisurely retreat into the woods, and was lost to view. I have heard of a similar instance of tameness occurring on our Downs.

The harvest-mouse (*mus minutus*). This pretty little creature is, in my opinion, the most elegant and interesting of our mice, and but for the pigmy shrew he might claim the distinction of being the smallest of British quadrupeds. Its length, including the tail, is only four inches eleven lines; its weight about the sixth part of an ounce. The surprising assertion is sometimes met with that it takes two harvest-mice to weigh down a halfpenny on the scale. This statement is made on the authority of Gilbert White, and though true in his time is true no longer; the halfpenny has considerably lessened in size since his book was written. Taking the weight of the modern halfpenny as the base of our calculation, this would give the weight of a mouse as the tenth of an ounce, which is absurd.

The extraordinary agility and lightness of the species now under consideration are almost incredible, and the nimble manner in which he will swarm up a stalk of grass or corn without breaking it must be seen to be believed. His unwearying activity is very surprising. I could hardly come near the cage where one of this species was confined without finding him busily occupied with some form of exercise or another. His favourite amusement was jumping up and down from a twig placed horizontally across his cage. I once counted him take as many as fifty jumps up and down, without pausing to take breath; the speed was very great, the eye being scarcely able to follow his movements. His time for sleeping seemed to be from twelve o'clock p.m. to nine o'clock in the morning.

This mouse is admirably suited for being kept as a pet; his beauty of colour, his lively habits, and especially the fact of his being active in the daytime, make him a very desirable addition to one's household. His surprising feats may thus be easily observed, and notice should be taken of his prehensile tail, with which he alone, of British mice, is endowed.

This member is of the greatest service to him. When walking on a bending twig, he passes it lightly along a neighbouring branch, and so steadies himself; he will even perform his toilette while swaying to and fro upon a stalk of corn, keeping his position solely by his hind feet and his tail twined round the stalk. One observer has seen him suspend himself entirely by the tail, after the fashion of some of the American monkeys. He differs from the monkeys who possess prehensile tails, inasmuch as the monkeys only grasp with the last few inches of their tails, which are devoid of hair on the under-surface of the tip and protected by a patch of callous skin. The harvest-mouse uses the entire length, which has a uniform covering of scales and minute hairs.

My little pet used to give us a most entertaining performance in a small tin bath. When first introduced into the arena he would run nimbly round, and then converting himself into a tripod by standing on his hind legs, and using his tail as the third support, he would endeavour to peer out upon the world. A little bowl of dried rose leaves would then be placed before him, when he would dive in head foremost, scattering the petals in all directions, and reappearing almost at once he would jump out and continue his rapid perambulations up and down his playground. On one occasion we put a stuffed mole into the bath, and his behaviour towards it was very amusing; he walked round it with mincing steps, suspiciously facing it all the time, and when it was made to advance upon him he sprang back alarmed.

His diet was of the simplest description—soaked bread, ripe fruit, corn of all sorts, grass seeds, caraway seeds, and nettle seeds. He was a bright example of the invigorating effects of a vegetarian diet; and though it is often said that the flesh-eating animals have more vigour than those whose vitality is expended in dealing with the more bulky nature of vegetable food, I never saw an animal who carried into practice the idea of perpetual motion so completely as little Henry, the harvest-mouse.

He was not a bigoted vegetarian, however, and on one occasion I saw him greatly relish a blue-bottle. He heard the sound of buzzing in his sleeping box, where I had put the fly, and he presently appeared with the insect in his mouth. It was devoured with great gusto at a single sitting; he rejected the head, legs, and hard covering of the abdomen. I kept him for some time in an ordinary wire mouse-cage, to which he became much attached; and, one day, when running loose on the floor of a room he was startled by a footstep, he ran at once for home.

Amongst themselves, I am told, they wage most determined battles. The males, in spring, will fight with great courage and fierceness; and when the conflict is decided, the one who is beaten is devoured by his successful antagonist.

One of the most interesting facts connected with the history of the harvest-mouse is the cleverly constructed nest. The description given by White is so invariably quoted in the Natural History books, that for the sake of variety, and also because it is a more exact description, I give Dr. Gloger's account of a nest which he had the opportunity of examining.

"It was beautifully and elaborately constructed of the panicles and leaves of three stems of the common reed woven together, and forming a roundish ball, suspended on the living plants at a height of about five inches from the ground. On the side opposite to the stems, rather below the middle, was a small aperture, which appeared to be closed during the absence of the parent, and was scarcely observable, even after one of the young had made its escape through it. The inside, when examined with the little finger, was found to be soft and warm, smooth and neatly rounded, but very confined. The nest contained but five young; but one, less elaborately formed, was found to contain no less than nine. The panicles and leaves of the grass were very artificially woven together, the latter being first slit by the little animal's teeth into more or less minute bands or strings. . . . It suffered considerable disturbance even from the most careful handling, losing in neatness of form as much as it gained in its increasing size."

It will be remembered that White says that the nest he saw was "so compact and well filled that it would roll across the table without being discomposed." These conflicting statements may be reconciled, if we bear in mind that, according to Brehm, these mice improve in the art of nest-building as they advance in age. Doubtless the nest described by White was the handiwork of an old and experienced mouse, while the one which formed the subject of Dr. Gloger's remarks was the crude production of a youngster.

In favourable situations two or three broods are reared every year, and allowing six or seven for an average litter, we can imagine how swiftly our little grain-stealers would increase, but for the unremitting attentions of cats and weasels, hawks and owls.

The dormouse (*myoxus avellanarius*). The dormouse occupies the position of a link between the squirrels and the mice. He is clothed with thick yellow fur, he has fine spreading whiskers, a full beady eye, and, unlike the mouse proper, he has his ears protected with fur. His tail, too, points to his affinity with the squirrel's; it has large thick vertebræ, and is covered with hair, though not so thickly as the squirrel's. He further resembles the squirrels by hibernating through the winter months.

As may be at once surmised by observing the mild and innocent expression of his countenance and his large eyes, the dormouse is a nocturnal animal, and a second glance at the relative shortness of his fore limbs will show that his habits are arboreal; like the squirrel, he spends most of his time among the branches. They exercise their activities in quite different spheres, however; for while the squirrel delights in the great trunks of forest trees, his paws being provided with hooklike claws, by which he clings to the rough bark, the dormouse feels more at home among the lesser branches of hazel and hawthorn, his paws being well adapted for grasping twigs. His behaviour while climbing up a stick is precisely like that of a squirrel; when he finds himself observed, he presses close to the bark and sidles round the stick, till he is quite hidden from the observer. By day the dormouse is very drowsy; but when fairly roused he is quick and active, and will take surprising leaps. One of my pets sprang at least fifteen inches of horizontal distance, from my hand to a coat hanging on a peg. The force of the jump was most noticeable to my hand. Should he miss his footing and fall, he takes no hurt; but spreading out limbs and tail to their fullest extent, he floats to the ground like a parachute and alights uninjured. In this, too, he resembles the squirrel.

I have seen one of these animals hang by his hind legs for a considerable time, using his fore paws to hold a nut to his mouth.

The hazel nut forms the staple food of the dormouse, from which fact he obtains his name of *avellanarius.* The kernels are extracted in a most workmanlike fashion, while he sits on his hind legs and holds the nut to his mouth with his paws. He first nibbles a small hole, which he gradually enlarges, until the whole contents have been scooped out with his long curved teeth.

The nest in which the young are reared is of a considerable size, and is built in a thick bush. The materials of which it is composed are grass, leaves, pine-needles or similar substances; and it has been recorded that they place a feather to serve as a door to the nest, which, by its elasticity, recovers its position when pushed aside by the outgoing or incoming dormouse, and, like a spring door, keeps out the draught from the interior. Young dormice are born blind, and are of a mousey grey colour, not attaining their yellow fur till the following spring.

The principle point of interest in the natural history of the dormouse is the faculty he has of sleeping through the cold weather in a state of torpor. The scientific name for this phenomenon is "hibernation." The country people of Suffolk call it the "sleeper," and the name "dormouse" is given in recognition of this curious habit (Latin *dormire*, to sleep).

As autumn approaches, he feeds very freely on the various fruits and nuts the season so bountifully provides; and as a consequence he soon increases to truly aldermanic proportions, until his form, never very elegant, resembles nothing so much as a round pincushion.

His next step is to interlace some grass blades, and construct a very compact little nest among the lower branches of a shrub, and at the first approach of cold weather, he falls into his death-like trance. He rolls himself into a tight ball, and lets his tail lie right over his head; his ears are flattened against his head, and look as if they had been pressed with a hot iron; his whiskers, too, are smoothed against his cheek. Everything seems arranged so as to expose as small a surface to the cold as possible. On taking him into your hand, you are surprised to find how cold he is; his temperature barely exceeds that of the surrounding atmosphere. His breathing is almost at a standstill, and the pulsations of the heart are intermittent and irregular.

While in this strange abnormal condition, he may be immersed in water for two hours, and yet take no harm, or he may be placed in a jar of carbonic acid gas and not be suffocated. In this state he can exist for weeks together without taking any food, depending only upon the deposit of fat which lies beneath the skin. In mild weather he wakes, and eats some of his store of nuts, but he always relapses into slumber upon any lowering of the temperature.

I have kept a pair of these mice four years in great contentment. In the winter they were usually kept in a warm room, and therefore did not sleep very profoundly; and even if kept in a cold room for a night, and showing all the signs of hibernation in the morning, they could always be waked by the heat of the hand in five or ten minutes.

By the end of four years, my dormice began to show traces of old age; their movements lost their former briskness, and their paws became wrinkled like the hands of an old man, until first one and then the other of the aged pair paid the debt to nature, and peacefully expired.

The short-tailed field-mouse (*arvicola agrestis*). This animal, more properly called the short-tailed field-vole, as the voles must not be confounded with the true Murinæ, has a strong relationship with the beaver, and resembles that animal in colour of fur, shape of skull, general contour, and to a certain extent in its water-frequenting habits. The ears are deeply sunk in the thick fur, the head is blunt and rounded, and offers a striking contrast to the sharp features of the common house-mouse. Its name of meadow-mouse indicates its place of abode; it is chiefly to be met with in hay-fields, and if the fields are in the neighbourhood of water, or are themselves swampy, the mice are so much the better satisfied. They have also been found inhabiting the deserted nest of a coot, which they shared with some water-shrews.

In the spring, when the grass has grown a few inches, the vole sets himself to the task of making a nest for the young, which are usually born in May. This nest is built upon the surface of the ground, and is usually placed in a slight hollow, so that the nest is half above the ground and half below. It is cleverly constructed from grass blades, which have been slit into their component fibres by the teeth of the little architect, and they form a very soft, warm bed for the naked pink mice which are born there.

It is a curious fact that both rabbit and field-vole choose a far more exposed situation for their nurseries than they do for their ordinary dwellings. The rabbit seems so careless for the safety of her young, that any person gifted with a long arm may easily reach the end of the burrow she excavates for them. The field-vole, as we have seen, places her young in a still more accessible position. I suggest the reason for this apparent carelessness to be that so many young creatures together would poison themselves by their own breath, unless the nest was built in an airy situation. I for my part should strongly object to make one of a party of warm, breathing mice, in a confined burrow a foot or more below the surface of the ground; asphyxiation of the entire family might, I think, be safely predicted.

The mothers are very devoted, and will sit so closely on their nest that they are often cut to pieces by the knives of the mowing machine. The surest way of trapping these mice is by finding a nest of young ones, which may easily be done in the proper season, and putting them into a trap; the mother will soon find her way in to them, though they are very diffident about entering a trap upon ordinary occasions.

These voles have been observed in the act of carrying their young from flooded meadows, in the same manner as a cat carries her kittens, and in all probability the young are removed below, in the event of rainstorms or other disturbances, to safety underground.

A student of voles can easily tell their haunts at a glance. The distinguishing marks of a vole-infested locality are principally the little passages trodden among the grass stems, often so matted overhead with various herbage as to be quite concealed from any eye looking at them from above. The chief enemy of voles is the kestrel hawk, who in his lofty flight keeps ever a watchful eye upon the ground, and is always on the look-out for unwary voles. It is this danger, I suppose, that accounts for their love of covert. If they are obliged to pass over open ground they run very swiftly, and so well does their colour harmonise with the earth, that they are quite invisible, except to the eye trained by observation, and that knows what to look for.

Another sign of the existence of voles in any given spot is to be found by turning over the large stones, if there happen to be any; if voles are present, you will find fresh grass blades and the leaves of various plants, which the timid vole has brought there to be consumed under cover. By sitting still in their haunts for a few moments, you may easily hear them eating on all sides; a subdued noise of tearing grass is distinctly audible, and you may see their red heads poking out of their holes.

With a strong trowel you may follow the course of their burrows, and sometimes track the little tenant into a *cul de sac;* but as a general rule the passages join one another in such a network, that they are able to find another way out. In these subterranean galleries may be found broken snail-shells (for the mice vary their diet with meat occasionally), and the curious cases which contain clover seed, also freshly cut grass; and after some persevering digging you may break in upon a little round chamber lined with soft hay, which forms the sheltered bed where the owner takes his repose.

Though in a general way mankind can afford to ignore this insignificant little creature, there are occasions when he becomes a very mischievous pest. The two most deadly enemies of the short-tailed field-vole are drought and floods: in dry seasons they perish for want of water, and when the low-lying meadows are overflowed they are drowned in their thousands. It sometimes happens that the season hits the happy medium, and as the voles are very prolific, and bring forth from four to six at a time, and have three or four litters a year, their numbers increase prodigiously. An instance of this taking place is recorded in the Book of Samuel, where we are told of the mice that marred the land of the Philistines; but in more modern times as well, they have made themselves conspicuous.

In the years 1813 and 1814, shortly after the formation of the royal plantations in the Forest of Dean and in the New Forest in Hampshire, a rapid increase in the number of voles threatened the existence of the young trees. Vast numbers of saplings were destroyed by having the bark stripped from them, and also by having the roots bitten through when they happened to block the way in the burrows of the swarming myriads. So great was the devastation, that Government was forced to step in and take measures for the protection of the forests. Various plans were tried; poison was laid, traps were set, and the help of puss was sought for and obtained, but to very little purpose. At last it was suggested that pits should be dug, which should be made wider at the bottom than at the top, and whose sides would therefore be too steep to climb. Numbers of such pits were dug accordingly, and into these the little vermin fell in such numbers that in the two districts 60,000 were caught in the space of four months, and paid for at a fixed rate per head. The Crown was, however, served far more efficiently by unpaid servants, self-constituted protectors of the young trees, in the persons of hawks, owls, magpies, crows, and other birds of kindred tastes, while stoats and weasels also took part in the carnage. Probably 200,000 perished in all, and the plague was stayed.

The vole is well fitted for his life in the open field, by having his eyes set very much on the top of his head, so that he may keep a good look-out for danger in the quarter from which it usually threatens, namely the sky. But while this provision is well enough to secure him from being a victim to the hawks, it renders him very liable to danger from pitfalls. The vole performs his daily activities with his gaze directed skywards, so that any sudden inequality in the surface of the ground sends him headlong. When kept in captivity they are always running over the edges of the table upon which you may place them to exercise, and a much-valued vole of mine killed himself by falling from a landing to the bottom of the house. The same thing holds good in respect of prairie dogs (who, be it remembered, are rodents like the voles), and I met with an account of some experiments a short time since, which consisted in placing these animals upon chairs and tables. The foolish creatures, accustomed to the boundless level prairie, at once started off at a brisk trot, and were greatly surprised to find themselves suddenly upon the floor.

The damage inflicted upon the young saplings reminds us again of its relation, the beaver, whose staple food is bark and young shoots of trees.

The vole does not hibernate during the winter, and its tracks may easily be seen in the snow. I have not been able to ascertain whether any food is stored for winter use, but

I imagine that hips gathered from the dog-rose, and berries of various sorts, with bark and buds, gathered as occasion requires, form his diet during the winter season.

The bank-vole (*arvicola glareolus*). For the sake of completeness, I will just mention the bank-vole, an animal that may well be mistaken for the short-tailed field-vole; it is chiefly distinguished from this near relation by having a longer tail.

It is common in the Leigh Woods, and I believe my dog killed an individual of this species on the Downs.

Hypnotism.

A Sketch of the Chief Phenomena.

By F. H. EDGEWORTH, M.B., B.Sc., B.A

THOUGH it is desirable to give an account of the phenomena of the hypnotic state before entering upon a discussion as to its nature, yet it may be well to begin by a short definition, so as to give some general idea of the subject.

The hypnotic state, then, may be defined as a state of the mind characterized by an increased susceptibility to suggestions. By "suggestion" is to be understood any event which produces a mental change by reason of the person believing that it will do so. For instance, suppose various persons be severally told, "There is a mouse behind you." One person will at once totally disbelieve the statement; another will turn round, and, not seeing any mouse, then disbelieve it; a third will, not seeing any mouse, fancy he does so, perhaps saying, "Did you see one?" whilst a fourth will say, "Yes, there it runs."

In normal individuals, then, this tendency to believe anything, independently of any logical connection between the suggestion and the belief, varies to an enormous degree.

The hypnotic state is one in which this suggestability is experimentally heightened.

The suggestion in the above instances is a verbal one, made by another person, who is called the hypnotiser, whilst the person to whom it is made is called the "subject."

Suggestions, however, may be of a somewhat different nature; thus if a person, in a room by himself, think that a slight noise he hears is made by a mouse, he will have a greater or less tendency to see it. The slight noise is, in this case, the suggestion. Again, if a person who is inclined to stammer think that he will do so on some particular occasion, he will stammer, notwithstanding any voluntary efforts to the contrary. The suggestion is, in this instance, an auto-suggestion.

When experiments, made at Nancy, were first published, showing what a large proportion of healthy persons are susceptible to hypnotic processes, there was a general disbelief in England that healthy persons, other than of French nationality, could be so influenced. But, as indeed might have been suspected from the fact that this suggestability—this tendency to believe without proof—is not a French characteristic merely, experiments made elsewhere have shown that the opinion was incorrect. Thus Wetterstrand, of Stockholm, out of 718 normal individuals, hypnotised 699 (97 per cent.); Van Renterghem, of Amsterdam, out of 178 normal individuals, hypnotised 162 (90 per cent.).

Again, corresponding to the age-variation of this normal suggestability, it has been shown by the Nancy school that up to the age of fourteen years all persons were influenced by hypnotic processes; and that, above this age, the number of refractory subjects gradually increased, so that at the age of forty years it was 12 per cent. This was also shown by the number of persons who passed the first time they were hypnotised into the deeper (somnambulistic) stage; at the age of fourteen years the percentage was 55, at thirty years 22, at forty years 10. The Nancy experimenters have also found, what unbelieving man had before doubted, that males and females are equally susceptible.

Methods of production of hypnosis may be divided into those which act by sensory stimulation, and those which act by direct suggestion of the state.

The sensory stimulation by which hypnosis is produced may be either sudden and intense, or continuous and slight. Thus some persons can be hypnotised by a sudden bright light or loud sound. It is, however, somewhat doubtful whether the condition so produced is a true hypnosis; it appears to be rather of the nature of a fright-paralysis, closely allied to Preyer's fright-catalepsy in animals, and the persons who can be so affected belong almost invariably to the class of hystero-epileptics.

The sensory stimulation, by which normal persons can be hypnotised, must be of a quite different nature; it may act on any one of the senses, and of these it would appear that the visual and tactile are most easily affected. Thus a much used method is Braid's: the person is told to gaze at some small object which may be bright and shining, *e.g.* a sixpenny-piece, or dull, *e.g.* the end of a penholder or the finger, and which may be held at any distance or level; for it is not necessary, as was once thought, to hold it a little above the person's eyes, so that they are strained by the effort of looking up. The so-called "fixation method" is merely a special case of the above. The "subject" is told to look steadily at the hypnotiser's eyes. The tactile sense may be stimulated in either of two ways, by direct contact or by "passes." In the first, the hypnotiser gently strokes some portion of the skin, *e.g.* forehead, with the hand; in the second, he moves the hand close to, but not touching, the skin of the subject. The exact way in which sensory stimulation is effected by these "passes" is disputed. Some have thought that it is by the air currents excited; others, that it is by the heat radiated from the hand, for this soon gets hot, owing to the muscular exertion; others, again, think that electrical currents are produced in the skin.

It is pretty certain that the sole element common to all these various methods is that they produce continuous slight sensory stimulation.

But hypnosis may be produced solely by the direct verbal suggestion of sleep; and this not only in persons who have been previously hypnotised by physical means, but also in persons who have never before been hypnotised. This is the now celebrated method of the Nancy school of experimenters. This most important fact gives rise to the question whether continuous sensory stimulation does not produce hypnosis by indirectly suggesting it, and not as such, acting physically only. And, except by the Salpetrière school, the following opinion is now held: that monotonous sensory stimulation of itself produces normal sleep; but that in hypnosis the essential thing is that the "subject" is sent to sleep by the hypnotiser, who may do this by indirect (monotonous sensory stimulation) or by direct (verbal) suggestion. And this corresponds to the difference between hypnosis and sleep; *i.e.* in the former there is, in the latter there is not, an increased suggestability to the hypnotiser.

Practically, it is sometimes found that "passes" have produced sleep, and not hypnosis.

To dehypnotise a person, either verbal suggestion or a sudden sensory stimulus may be employed. Thus one may say, two or three times, "Wake up," or "Count up to ten: when you say 'ten,' you will wake up"; or one may blow suddenly on the face, or shake the person. This will almost invariably succeed; very occasionally it has been found not possible, and then one must wait—the person gradually passes into a normal sleep, and spontaneously awakes.

Stages of the hypnotic state exist. Various somewhat elaborate classifications of these have been given. The simplest, however, and one which is very probably generally true, is based on the remembrance of what has occurred during hypnosis. This method divides hypnosis into a pre-somnambulistic and a somnambulistic stage. If a person has been only in the pre-somnambulistic stage, he will, on resuming his normal condition, remember everything that has occurred during that state. On the other hand, if he has entered into the deeper somnambulistic stage, he will afterwards not remember, or but dimly, what has occurred during it.

The first time, perhaps, a person is hypnotised, he may only enter into the earlier, lighter stage; the next time he passes on into the deeper stage. And as what may be termed his "hypnotic education" increases, the first stage shortens, so that at length the command, "Sleep," sends the subject at once into a state of somnambulism.

It has also been proposed to divide hypnosis into two stages, in the first of which there is only suggestability for movements, and a second deeper stage in which there is in addition suggestability for the senses, *i.e.* hallucinations may be excited. This method of classification, however, is nearly, though not quite, identical with the one just described; the first stage corresponding to the pre-somnambulistic, the second with the somnambulistic, stage. In some "subjects," however, it is possible to evoke hallucinations which are remembered, *i.e.* which occurred in the pre-somnambulistic stage.

(This use of the word "somnambulism," or "induced somnambulism," must be distinguished from two other meanings which have been attached to it. There is Charcot's "somnambulism," an asserted special hypnotic state, to be afterwards described; and "somnambulism," or "natural somnambulism," which is commonly called "sleep-walking.")

Classes of suggestions.—It is possible to classify in various ways the suggestions which may be made to a hypnotised person. Thus we may do so according to the sense organ by which they are received. For instance, the suggestion that a person's right hand is insensitive may be either by word of mouth or by writing; he receives it in the one case through the ear, in the other through the eye.

In connection with this a somewhat important point may be mentioned. It is found that in hypnosis, just as in normal life, impressions are deepened, intensified, if they are received through more than one sense organ; thus the performance of a suggestion of movement, or the acceptation of a suggested hallucination, is facilitated by making the subject act in accordance with it. For instance, I tell a "subject" to walk to the other end of the room. If now he be started on his way by a push, or if he hear me "marking time," he more readily goes than on the mere verbal suggestion; or, again, if a "subject" be told he is a politician, and must make a speech, he often does not readily accept the suggestion, although if he be made to begin speaking, he gradually assumes the suggested *rôle.*

Suggestions may also be classified according to the result aimed at; thus one may give the "subject" the suggestion of some movement to be executed, or of some object to be perceived (hallucination). Again, they may be divided into two classes—imperative and inhibitory (or paralytic). Imperative suggestions are those which cause the production of some mental phenomenon ; *e.g.* the perception of a colour, or the impulse to make a movement. Inhibitory suggestions are those which cause the cessation of some mental phenomenon ; *e.g.* the loss of the power of seeing blue, or the impossibility of bending the arm.

Unconscious suggestion.—It is very easy to draw erroneous conclusions in making experiments on hypnotised persons, owing to the difficulty there is of being sure that the result obtained is due to the given suggestion only, and that it may not have its origin in other unintentional suggestions as well. For, in accordance with the law of expectant attention, it is difficult not to give some hint, consciously or unconsciously, as to the expected result. This is perceived by the subject, who reacts correspondingly.

To this source are due many errors in the statements of Heidenhain and of the Salpetrière school as to the physiological characteristics of the hypnotic state. Thus it was asserted that, if the right arm of a "subject" be paralysed by suggestion, and a magnet be then brought into contact with it, the paralysis is transferred to the opposite arm. It has, however, been shown that if a piece of brass were used, the "subject" believing it to be a magnet, the transference took place ; and, conversely, if the person were led to believe that the magnet was a piece of brass, the transference did not take place. The results, then, were due to the hypnotiser thinking that a magnet would effect such a transference, and unconsciously betraying this belief to the "subject."

Voluntary muscular system. Without suggestion.—If no suggestion be made, a hypnotised person may either move freely (so-called "active hypnosis") ; or, on the other hand, present the aspect of being asleep, with infrequent or no spontaneous movements ("passive hypnosis") ; or, as is usually the case, be in one of the many states between these two extremes. The exact causes of these variations are not fully known—though it would appear that they are dependent in some degree on the method by which hypnosis has been produced, on the stage of hypnosis, and on the individuality of the person.

With suggestion.—Suggestions of movements, either imperative or inhibitory, may be given him. Imperative suggestions of movements given in the earlier stages of hypnosis cause some movements to be performed, and not others. Thus it may be possible to make him close his eyes, but not bend his arm. But if hypnosis be deep enough, an imperative suggestion will make the person perform any voluntary movement, *e.g.* walk to the end of the room to fetch anything; and, finally, suggestions which are but barely imperative succeed, so that the "subject" obeys the slightest gesture, provided that he understands it. The general rule is, that we can first make him do acts which are usually carried out reflexly (*e.g.* shutting the eyes), then acts which are rarely, and finally acts which are usually, carried out voluntarily.

Imitated movements are merely a special case of these imperative suggestions. If standing before a hypnotised person I raise my arm, he does nothing; if I do so, saying, "Put out your arm," the "subject" raises his; if now, without saying anything, I raise my arm, he does so too. And with a little training, the "subject" readily becomes a *Spiegelbild* of the hypnotiser. These imitated movements are evidently the result of imperative suggestions perceived through the visual sense. Similarly the "subject" may be taught to repeat everything the hypnotiser says, whether understood or not (*Echolalie*).

"Suggestive catalepsy" may here be spoken of, as it is a phenomenon closely allied to these imperative suggestions of movements. For instance, I tell a hypnotised person to put his arm in some position, and then tell him that it is getting stiff, so that he cannot move it; if this suggestion be accepted, the arm becomes rigid in the position assumed, and the muscles will be found, on examination, contracted so as to hold it so. The arm is then said to be in a state of suggestive catalepsy. Similarly any part or the whole of the body may be put into a state of suggestive catalepsy in any desired position. It is found that the development of this condition is often facilitated by making passes over the part of the body to be affected; these almost certainly act merely by strongly directing the "subject's" attention to the part, and not by any local stimulation of the muscles affected.

These imperative suggestions have been of some act to be done, or of some position to be retained; they may, however, take another form—of increased muscular strength. Thus, on the suggestion, the "subject" will be able to squeeze a dynamometer harder than he can in his normal state.

Inhibitory suggestions of movements are found to be accepted in the same order as are imperative suggestions. Thus it is easier to prevent a "subject" taking a deep breath than closing his hand. And, finally, it is possible to inhibit any movement by suggestion. Also one may inhibit not merely some simple action, but some group of actions, co-ordinated together for some special purpose, *e.g.* writing (producing agraphia), or sewing. It is found that, although the person can move his hand freely for all other purposes, he cannot do this particular thing. This comes out still more clearly if, *e.g.*, he be told he cannot write the letter *a*; it is then seen that, whilst all other letters are correctly written, the *a*'s are left out, as he copies a few lines from a book or writes from dictation.

An inhibitory suggestion may also affect, not a movement or group of movements, but a whole limb. Thus if a "subject" be told he cannot move his right arm, he loses power over it.

Such suggestive paralyses, and also those described just above, present the closest analogies to hysterical and other functional paralyses of movement.

A curious circumstance is that an imperative or inhibitory suggestion of movement occasionally persists; *i.e.* cannot be immediately removed by a contrary suggestion. Thus if a "subject" be told he cannot bend his arm, he finds he cannot do so; on being told he now can, he generally can do so immediately, but occasionally some little time elapses before this is possible. Or, again, if told to twist his hands one round the other, and then to stop, he does not always immediately do so. These facts are paralleled by many interesting occurrences in health and disease.

Involuntary muscular system.—In normal life, with rare exceptions, the muscular system of the heart and blood-vessels cannot be acted on by direct volitional effort, though they are delicately responsive to those mental phenomena which have a marked emotional character.

During hypnosis, however, it is otherwise; thus, by direct suggestion, the rate of the heart's beat can be increased or decreased. It was at first thought, on the discovery of this, that the result was indirect—due to some emotion; but inasmuch as not the slightest change occurs in the respiration, it appears to be the direct result of suggestion. (It need hardly be said that experiments of this kind should not rashly be repeated.) Similarly, by direct suggestion, a local pallor or blush may be brought about. Further, the following remarkable results have been observed in France, in the course of experimenting on very sensitive subjects. Letters were traced by the finger of the hypnotiser on the skin of the "subject's" arm, and the suggestion was made that these should appear as letters of blood. Watch was kept on the person in the wards of a hospital to prevent any deception being practised; and it was found, at the end of twenty-four hours, that little drops of blood were oozing from the skin, marking out the letters previously traced. Again, on the skin of a hypnotised "subject," a postage stamp was fixed, the suggestion being made that it was a blister. In a short space of time distinct vesication and ulceration occurred.

These results are most interesting, inasmuch as they are vaso-motor and trophic phenomena, the direct outcome of hypnotic suggestion, *i.e.* of mental origin. They enlarge our conceptions of the enormous influence that mental occurrences have on the body. Further, they offer a satisfactory explication of those hitherto most obscure phenomena—stigmata,* and of events analogous to these.

Hallucination and illusion.—Before describing the sensory condition of a person in the hypnotic state, it will be well to shortly discuss the meanings of the words hallucination and illusion.

To make matters simpler, we will take visual hallucinations and illusions only.

We may first dismiss with a few words that class of visual hallucinations which are generally due to nervous impulses continuing to pass up from the eye to the brain after the object which excited the retina has been removed. Thus if we glance at the sun, and then look away, we "see the sun" for some little time afterwards. We have an

---

* See, for an interesting account of this strange by-path of religious enthusiasm, the article by Macalister, "Stigmata," in the ninth edition of the *Encyclopædia Britannica*.

"after-image." This class of hallucinations has other characteristics, differing from those of the hallucinations to be immediately described, but which need not be further insisted on here (*vide* note at end of paper).

The origin of visual hallucinations other than these may, in the first place, be auto-suggestion. Thus a visual recollection may arise in the mind. This may remain subjective. If, however, its origin is not recognised, it is generally "projected," *i.e.* supposed to be due to some external object, and is called an hallucination. (It may be remarked, in passing, that, by persons of great visualising powers, visual recollections may be voluntarily projected; these would not come under the definition of hallucinations.) In the second place, such a visual hallucination may have its origin in suggestion from without, as in the instances given in the first part of this paper, where the hallucination of a mouse was due in the first case to a verbal suggestion, in the second to a misinterpreted noise.

We may define, then, a visual hallucination as a visual image which is believed to be due, though it really is not, to a corresponding external object, and which has its origin in auto-suggestion or in suggestion from without.

This "projection" of an hallucination may take place in either of two ways. Thus if a hypnotised person was told, "Look, there is a dog," he might say he saw it running about the room, or he might think that some piece of furniture, *e.g.* a footstool, was the dog, erroneously interpreting the visual sensations due to the footstool. In the latter case, then, the hallucination is "projected" upon the footstool, which is called the *point de repère.* In the latter case it will be evident that the hallucination will obey all tests of visual perception of a real object; *e.g.* if he look at the imagined dog, with a prism placed before one eye, he will see two footstools, and consequently two dogs. In the former case, where there is no *point de repère*, one of two things may occur, if a prism be placed before one eye. If the person sees that real objects are doubled, he may infer that the dog is also doubled. If, however, he be so situated that the objects really perceived are such as cannot be doubled by the prism, he will not infer that the hallucination is doubled (*e.g.* if the hallucination be that of a bird, and he be looking up at a cloudless sky).

Such a visual hallucination will, in accordance with the law of association of ideas, lead to the development of hallucinations of the other senses. Thus if a person see an (imaginary) canary bird, he will soon hear it sing; the visual hallucination calls up, suggests, the auditory. These associated hallucinations will depend on the strength of the primary one. For instance, suppose a person see an (imaginary) dog lying on the hearthrug, and attempt to stroke it, the absence of tactile sensations may suffice to dispel the visual hallucination; if, however, this be strong, the person will think he touches the dog, *i.e.* associated tactile hallucinations occur. Again, if he thinks the footstool is the dog (hallucination with *point de repère*), then touching this may suffice to dispel the visual hallucination; but if this be strong, the person misinterprets these, and thinks he strokes the animal.

All these hallucinations are "positive"; *i.e.* the person thinks he sees some object which really is not there. They may, however, be negative; *i.e.* in consequence of an auto-suggestion, or suggestion from without, the person does not perceive some object which actually is present. Instances of this are probably much more numerous in everyday life than are positive hallucinations; thus it often happens that we do not see something because we think it is situated elsewhere. The sensations due to the object are not perceived, because they do not correspond with the present mental phenomena.

Just as in the case of positive, these negative hallucinations may be suppressed by the evidence of the other senses, or if sufficiently strong, associated negative hallucinations occur.

It remains to speak of visual illusions. These may be defined as visual hallucinations which are due to suggestion from the object which is seen, and not to auto-suggestion or to suggestion received through any other sense. Further, the hallucination so excited is always the sum of positive and negative hallucinations. For instance, suppose a short-sighted person does not accurately see some one in the distance; the sensations he receives may suggest to him that he sees some one else. This belief will lead him to suppress those sensations which do not, and to add those which do, agree with his memories of the person he thinks he sees; so that the illusion becomes rounded off and perfect.

(It may be remarked that some English psychologists extend this use of the word "illusion" so as to include what has been called here "hallucinations with a *point de repère*," and which, it may have been noticed, have this in common with "illusions," that actually they are the sum of positive and negative hallucinations.)

Senses. Without suggestion.—It would appear that, as a rule, no alteration takes place in the acuity of the senses in either the pre-somnambulistic or somnambulistic stage, unless some suggestion be made. It is, however, somewhat difficult to be certain, insomuch as in testing this some suggestion may involuntarily be given, and accepted by the "subject" owing to his increased suggestability.

With suggestion.—As was stated above, "subjects" rarely accept suggestions regarding the senses, unless they are in the somnambulistic state.

As to the alterations which may be so produced, we may, in the first place, heighten or lessen the acuity, produce a hyperæsthesia or anæsthesia, of any sense. Thus we may suggest an increased visual or tactile acuity, and then find that the "subject" reacts to much smaller stimuli than he does in the waking state. Probably many of the phenomena of so-called "clairvoyance" and "transposition of the senses" are really due to this suggestive hyperæsthesia. Similarly we may heighten the power of smell. Thus a "subject" of Carpenter's was able to pick out the glove of a certain person from sixty others, though he was not able to do this when his nostrils were plugged with cotton-wool.

Conversely, we may produce anæsthesia by suggestion. Thus numerous surgical operations have been done on persons in this state of suggestive anæsthesia of general sensibility; for instance, by Elliotson, in India, in 1845–6, *i.e.* in pre-chloroform days.

The suggested loss of the muscular sense is very interesting; thus, suppose a person be told that he is ignorant of the position of his right arm, though he can move it freely and feel when touched. It will be found that, as long as his eyes are open, he knows the position of his arm (*i.e.* because he can see it), but that if his eyes be closed, he does not; *e.g.* if he be told to touch his opposite hand, he passes his right hand across his chest and down the left arm to the hand, *i.e.* guiding himself by the sense of touch (in technical language, his arm is "ataxic").

These suggestive anæsthesias, it may be remarked, present the closest analogies to those which may occur in hysteria.

We may, however, produce by suggestion not an increased or lessened acuity, but hallucinations, of the senses. Since these are identical with non-hypnotic hallucinations, it will not be necessary to say much about them. The following, however, are interesting examples: I take a dozen white cards, all precisely alike to an ordinary person, and showing them to the subject, say, "Here is a portrait of the Queen on this card." Having marked the back of this, I mix them up, and lay them, face up, before the subject; he quickly picks out the marked (on the back) card as being the portrait. This can only have been done by associating minute markings on the card with points of the imagined portrait. It will be noticed that he looks closely at the card, and takes some little time to judge. It is a case of hallucination with *point de repère.*

It is found that, as in this case, the time necessary for the recognition of an hallucination with *point de repère* is greater than for a real object, and that it rapidly increases with lapse of time; thus the "subject" soon begins to forget the markings on the card, so that the portrait fades.

We may easily prove the absence of simulation by the "subject" in the case of these hallucinations. Suppose, for instance, he be told that a piece of an onion was an apple, it will be found that his eyes will not water, if he sniff at it; and conversely he will sneeze if he think that some burnt cork he sniffs at is really snuff.

We may test the intensity of the hallucination in other ways. *E.g.*, let a "subject" be told that a certain person is gone out of the room, and then let him be asked to count the number of persons present; he will say "five" (there being really six). If now he be told to look intently in the direction of the person, he may perceive him, and say, "Oh! there are six; I didn't notice him," or he may still not see him. In the latter case the "subject" may be told to walk in the direction of the person: on coming up close to or against him, he may recognise his presence; or he may not do so, not recognising the nature of the object with which he comes into contact. Thus varying inversely with the strength of this primary "negative" hallucination is the power of suppressing it by the testimony of the senses; if it be sufficiently strong, it leads to the development of correlated hallucinations of the other senses.

The following hallucinations, though more or less analogous to these hallucinations of the senses, are of a more obscure nature: A subject may, for instance, be told he is very tired or very thirsty; he gives every sign of experiencing these sensations. Thus, appetite, loss of appetite, dislike to some particular article of food or drink, can be suggested. Suggestions, too, succeed if they concern the emotions—sadness, gladness, love, hate, scorn, may be so excited. For instance, suppose an hallucination of a tiger were suggested, the person not only says he sees it, but presents all the signs of great fear; the hallucination is not merely of the external senses, it is an idea which takes possession of the whole mind.

It would appear, then, that by hypnotic suggestion we can, if the "subject" be in a sufficiently deep stage, bring about any mental phenomena of which he is capable.

Memory. Without suggestion.—The amnesia of a "subject" on awakening from the somnambulistic state has already been treated of in describing the stages of hypnosis. There are, however, some additional points which have not yet been touched upon: it is found that during somnambulism the subject remembers the events of previous somnambulistic states and of his normal life. It is to the former of these that we must attribute the increased suggestability of the subject in each succeeding hypnosis. These phenomena, which have given rise to the expression "dual consciousness," are, as is well known, paralleled by cases of spontaneously occurring phenomena in the mental life of some individuals.

With suggestion.—By suggestion, however, various alterations in the memory can be brought about. Thus, if a subject in a state of somnambulism be told that, on awakening, he will remember the events of that hypnotic state, he does so—there is no subsequent amnesia. By suggestion, then, we can abolish this " dual consciousness."

Again, by suggestion, it is possible during hypnosis to produce an amnesia or hyperamnesia for events of the person's past life. Thus if a person did not remember what he had eaten for dinner two days before and were hypnotised, he would, on suggestion, recall this, down to the smallest details. Another might be made to forget his age, name, and where he lived.

Or a paramnesia may be suggested. Thus a "subject" was told he had just run half a mile; he immediately presented corresponding signs of distress, with quickened breathing and pulse. Another was told he had had nothing to eat that day; he said he was very hungry, and ate ravenously of food placed before him—and this though he had had a good meal a couple of hours previously.

It is to this amnesia and paramnesia on suggestion that are due the marked differences in reaction to suggestion between persons in the pre-somnambulistic and somnambulistic states. Thus if a "subject" in the first state were told he would pronounce all *a*'s as *e*'s, he would do so, but would be annoyed at his *bêtise*; if he is in the somnambulistic state, he pronounces the *a*'s as *e*'s without evincing the least sign of annoyance, the suggestion that he should do so having made him forget what he had before learned.

To this, again, are partly due those remarkable transformations in character which can be effected by suggestion in very sensitive subjects. Thus a servant-girl was told, in the hypnotic state, that she was her mistress: she acted in accordance with this, imitating the voice, attitude, gestures of her mistress, and complaining of the faults of her servant (herself). Another woman, aged thirty, was told she was eight years old: she behaved like a little child, played with her doll, asked for mamma in a childish voice, etc.

It is clear that for this to happen two things are necessary: the "subject" must forget who he is; and, secondly, believing himself to be the person suggested, act in accordance with this. His representation will vary with the accuracy of his observations and with the vividness of his recollections.

Similarly a "subject" can be made to imagine he is an animal, *e.g.* dog or wolf. Such transformations remind us, and afford a partial explanation, of those remarkable epidemics of zoo-anthropomorphism of the Middle Ages.

Post-hypnotic suggestions.—Hitherto I have only described the characteristics of, and the result of suggestions during, the hypnotic state. Such suggestions were accepted immediately during that hypnosis. They may however be given, together with the additional suggestion that they are to be realised not then but later on, at some time subsequent to the hypnosis. These are termed post-hypnotic suggestions.

From the characteristics, above described, of the pre-somnambulistic and somnambulistic stages, it will be evident that a suggestion given in the first state will be consciously remembered; in the second, not.

I will first take post-hypnotic suggestions of movements given in the latter state. These may be "continued," to be done immediately hypnosis ends, *e.g.* "When you wake you will begin counting, and count up to ten"; or they may be "deferred," to be done after an interval, *e.g.* "Half an hour after you wake you will get up, saying, 'How hot it is!' and open the window."

The time at which such a deferred post-hypnotic suggestion is to be realised may be fixed in various ways: by an external sign, as, "When I rub my hands together you will cough"; or at a given day or hour, as, "You will come to see me on June 30th, at 10 a.m."; or, lastly, at the end of a given interval of time, as, "Half an hour after you wake, you will be unable to speak for five minutes." As might be expected, whereas the two former suggestions, if executed, are done punctually, the last kind are not always so; thus the half-hour above may be actually twenty minutes or forty-five minutes, evidently owing to the person's defective appreciation of time.

A most important point for consideration is the state of the person whilst performing these post-hypnotic suggestions. It appears, on investigation, that one of several events may occur: the "subject" may, at the appointed time, enter (spontaneously) into a state of hypnosis (somnambulism), and in this do the suggested act, or he may do it in a normal condition. If he falls into the somnambulistic condition, he may, though this is rare, continue in it and have to be awakened; but, generally speaking, as soon as the suggested act is done, he spontaneously awakes. If there is renewed suggestability during the performance of a post-hypnotic suggestion, and amnesia subsequently, we judge the person to have done it in the somnambulistic condition. The act may, however, be of such a nature that too short a time is taken in its performance for one to find out whether there is renewed suggestability; the subsequent amnesia is then the best test of hypnosis.

The conditions determining whether a person enters, or does not enter, into the hypnotic state during the performance of a post-hypnotic suggestion are not fully known. At the time of giving it, the additions may be made, "When you do this you will be fully awake," or "fast asleep"; but if neither of these suggestions be given, the person in some cases enters afresh into the hypnotic state, in others does not.

If a post-hypnotic suggestion be carried out in a waking condition, the subject may either think he has done it of his own free will, giving, if asked, some imagined reason for his action; or he may suddenly have the impulse, he knows not why, to do the suggested action, and will, if asked for an explanation, perhaps say, "The idea suddenly struck me." Which of these explanations is given depends very much on the person's self-observation, and on the naturalness or absurdity of the action.

If the action be very foreign to his nature, he may struggle some little while against the suggestion. These present many analogies to those impulsive actions, sometimes quite contrary to a person's character, which are occasionally done independently of hypnotic suggestion.

The length of time which intervenes between the giving and the performance of a deferred suggestion may be very long; in one instance it was over a year.

As an almost universal rule the person, in this interval, is in a perfect normal condition. He appears to be, if indirectly questioned, quite unconscious of what he will do, and if directly questioned, will deny that he has the least intention of so doing.

Post-hypnotic suggestions, given to a person in a state of somnambulism, may be not only of movements, but of hallucinations, or of any mental change which can be effected by suggestion during hypnosis.

Post-hypnotic suggestions of movements, but of these only, may be given in the pre-somnambulistic state; in this case the subject never passes into a hypnotic state whilst performing the action, but does it consciously—recognising the origin of the impulse, but not being able to resist it.

Theoretical.—We have in the foregoing part of this paper shortly described the most characteristic phenomena of the hypnotic state. The much more difficult task now is to attempt to give some general idea of the origin and nature of this curious mental condition, and of its relations with other mental phenomena occurring in the individual. We may best commence this by comparing hypnosis with the allied condition of sleep.

It has been shown that, in the pre-somnambulistic stage of hypnosis, consciousness and memory are intact, and that the alteration is the gradual loss of control over the voluntary movements. In the first stages of sleep, however, it cannot be said that this is the case; consciousness and memory gradually fail, concurrently with loss of control over voluntary movements. The analogy is closer with the stages of awakening from sleep, in which our power over voluntary movements is often the last thing to occur, long after consciousness and memory have returned.

If, however, we compare the somnambulistic stage of hypnosis with sleep, the resemblances are much more numerous. In both there is a more or less complete amnesia on awakening, and yet in neither is mental activity during the period wanting. During sleep we dream (except apparently in its very deepest stages); during hypnosis sequences of mental operations occur on suggestion, which have great resemblances with dreams. The differences of origin between these is quantitative only, dreams being more frequently excited by sensory stimulation than by verbal suggestion, whilst in hypnosis the contrary is the case. The contents are similar: sequences of mental events take place which are determined by the laws of association of ideas and not by voluntary control, the sensory elements of which have an hallucinatory character. The differences between these sleep-dreams and "hypnosis-dreams" are chiefly two: firstly, the motor results of sleep-dreams are mostly wanting—we rarely speak or move in dreams, though, as is well known, both of these results may be present (*e.g.* in sleep-walking), whereas the motor elements of "hypnosis-dreams" are fruitful in outward results; and, secondly, the sequence of mental events in sleep-dreams is not nearly so logical—we rapidly pass from one unfinished dream to another, whilst in hypnosis the reverse is the case. This is probably due to the difference in origin: in "hypnosis-dreams" the attention is fixed upon the hypnotiser, who suggests what train of ideas is to be followed, whilst in sleep-dreams the ideas are either due to auto-suggestion, or are called forth by some sensory stimulation which is subject to constant change.

The resemblances between sleep and hypnosis come out clearly, if we regard the matter from another point of view. We say that a post-hypnotic suggestion given in a state of somnambulism is not consciously remembered, and that the events which had occurred in one state of somnambulism were remembered in the next, but not in the interval. The remembrance must, then, have persisted, though not consciously; it must have sunk in the interval into that order of mental events which occur below the level of consciousness. For it is pretty certain that we are conscious of, know at the time, only a small portion of the mental changes which are going on in us, and that by far the larger portion of our mental phenomena are subconscious. From this point of view, then, hypnosis and sleep may be considered as states in which mental phenomena of this subconscious order are brought to light, to sink into their normal position as soon as the person resumes his waking state.

It has been sought in various ways to obtain evidence of the existence in the interval of these post-hypnotic suggestions as subconscious recollections. This has been best done by "automatic writing." If a pencil be placed in the hand of a person in the writing position, on a sheet ot paper, and the attention of the person be elsewhere directed, *e.g.* by conversation, it will be found that the hand moves, making often only inexplicable scrawls, but writing sometimes—even whole sentences—and this quite independently of any conscious voluntary effort on the part of the person. To put the matter shortly, it may at once be said that this "automatic writing" has been shown, pretty conclusively, to be merely the expression of subconscious operations going on in the person's mind. By this means it has been shown that the post-hypnotic suggestion—both what, and the time at which, it is to be done—persists as a subconscious idea during the interval between the reception and execution of the suggestion.

Such a post-hypnotic idea may be carried out subconsciously (this is generally the case, if the suggestion be one of some so-called "automatic" movement, as, "When I tap with my foot you will scratch your forehead"), and so be always subconscious; on the other hand, it may be that the person does, *e.g.*, the suggested act consciously—in this case the subconsciously remembered suggestion passes at the time of execution into the realm of conscious phenomena; or the person may, at the given time, enter spontaneously into a state of somnambulism, and in this do the act—in this case the upper stratum of mental operations so to speak, that illumined by consciousness, disappears temporarily, just as it does in hypnosis and sleep.

The phenomena of hypnotism may, however, be regarded from a different point of view. Suppose we take the instance given at the beginning of the paper: "There is a mouse behind you." The tendency to see the mouse—for an hallucination to arise—is in direct proportion to the belief that the mouse is there. Now this will vary inversely with the possibility of suppressing it by bringing to bear other considerations, whether derived from an *a priori* improbability or from the testimony of the senses. From this point of view then we may say that the suggestability of a person depends on the failure of contrary, inhibiting suggestions. The hypnotic condition is one of a more or less pronounced "monoideasmus"; in other words, the field of attention is narrowed.

To explain the bodily—motor and trophic (*e.g.* stigmata)—phenomena which result from the acceptance of the corresponding suggestion, a well-known law, that of expectant attention, must be considered. This is, that if we expect any phenomenon in ourselves—whether mental or physical—to take place, there is a tendency for it to do so. For instance, contrast the results of wishing, and expecting, to go to sleep. Suppose now that the suggestion be made to a hypnotised person, that his right arm is bending: in the first place the belief that it is doing so is uncontrolled by any contrary ideas (as explained above), it takes possession, so to speak, of his whole mind; and then, in accordance with this law of expectant attention, his arm does begin to move.

It is obvious that this law has limits; *e.g.* if a man's spinal cord had been accidentally crushed, it is clear that, no matter how strong his belief was that his leg was moving, it would not do so. However, the facts described above as resulting from hypnotic suggestion show that its limits are much wider than had hitherto been supposed.

The *uses of hypnotic suggestion* can only be shortly discussed here, as the subject is one rather of medical than of general interest. Owing to the fact that, parallel with mental phenomena, corresponding changes occur in certain parts of the brain, it is possible to exert an enormous influence, by means of hypnotic and post-hypnotic suggestion, over not only the mental phenomena of a person, but also indirectly over the majority of those bodily functions which are controlled by the nervous system. It is possible, as Forel says, to work upon the body of a hypnotised person, using his brain as the instrument.

The diseases which can be so cured, or, at any rate, relieved, are mostly of a functional or hysterical nature, *i.e.* are not dependent on structural alterations in the nervous system. For instance, hysterical aphonia, and other paralyses of sensation and movement, habit-tricks, stammering, writer's cramp, alcoholism, sleeplessness, unquiet dreams, some headaches, and various kinds of "neuralgic" and "rheumatic" pains can be so treated. It is probable, indeed, that many of these (though not all) have their origin in conscious or subconscious auto-suggestion.

Various objections have been raised to this employment of hypnotic suggestion as a therapeutic agent. The possible dangers are, however, only two in number. The first is, that on awakening from hypnosis, the person may complain of headache, lassitude, sleepiness, etc.; this can be easily avoided by suggesting, before awakening him, that he will afterwards feel quite well. The second more serious danger is, that the person, if hypnotised often (which is indeed very seldom necessary), may become very susceptible to hypnotic processes, so that possibly some unscrupulous person might take advantage of it for a nefarious purpose. This danger can and should always be avoided by giving the person, before awakening him, the suggestion that he cannot be hypnotised against his will by any one, or that he is only suggestable to the present hypnotiser. The Nancy school have shown that by these means the possible dangers of hypnosis can be rendered quite inappreciable.

These remarkable results of hypnotic suggestion evidently afford a sufficient explanation of the many "faith-cures" which are recorded as having been wrought, in all ages, at various shrines, and of which even to-day, as at Lourdes, false interpretations are given.

Charcot's three stages.—Charcot has described three stages of hypnosis : lethargy, catalepsy, somnambulism. The *lethargic* state is produced by the person fixing his eyes on a moderately bright object, or by pressure on the eyes. The person appears as if profoundly asleep, with relaxed muscles and eyes nearly or quite closed. Verbal suggestions are not accepted. The most characteristic feature is a hyperexcitability of the muscles and nerves, so that if a muscle be pressed on, it contracts, or if a nerve be compressed the muscles supplied by it contract ; *e.g.* if the ulnar nerve be pressed upon at the elbow, the *griffe cubitale* is produced. The *cataleptic* state may be brought about by a sudden sensory stimulus ; *e.g.* by a loud sound as given by a gong, or by opening the eyes of a person in a lethargic state. The eyes are widely open, with a staring, impassive gaze. Verbal suggestions have little if any effect. The characteristic feature is that the limbs preserve the attitude in which they are placed, and any one of these attitudes can be easily altered to another, the limbs feeling as if made of wax—a *flexilibitas cerea.* The *somnambulistic* state is produced by continuous feeble sensory stimuli, or by suggestion of sleep ;

or, if the subject be in a state of lethargy or catalepsy, by gently rubbing the top of the head. The most characteristic feature is, that though there is no neuro-muscular hyperexcitability, as in the lethargic state, yet gentle stimulation of the skin, as by blowing on it, or by stroking it, produces a contraction of the underlying muscles, which differs from that of the lethargic state, in that it does not give way on excitation of the opponents, and from the cataleptic *flexibilitas cerea* in that they oppose a resistance if any attempt be made to change the position of the limb.

In considering these views, the most important point to remark is, that they do not originate from suggestion; and also that the characteristic phenomena of each state—the neuro-muscular hyperexcitability of the lethargic state, the *flexibilitas cerea* of the cataleptic state, the increased cutaneous reflexes of the somnambulistic state—are physical, that mental suggestion has nothing to do with their production.

As is well known, these views have met with the greatest opposition. In the first place, Lièbault, of Nancy, in over 6,000 subjects never found these stages; Wetterstrand, of Stockholm, in 3,580 subjects never saw them; again, even at the Salpetrière they are very infrequent: Binet and Féré say that only two cases occurred in twelve years. In the second place, now that we know, thanks to the Nancy school, the great influence that psychical suggestion plays in producing the phenomena of the hypnotic state, it is easy to see into what pitfalls one may fall. Thus even the Salpetrière school admit that the contraction of underlying muscles on gentle stimulation of the skin in the somnambulistic state can only be evoked by the hypnotiser; this evidently shows that the phenomenon is a psychical, not a physical reflex. Again, the Salpetrière school rely on the insusceptibility to verbal suggestion in the lethargic state as evidence tending to show that that suggestion cannot have any influence in the production of the neuro-muscular hyperexcitability: the ease, however, with which the subject wakes up on the simple verbal command, "Wake," shows that we cannot exclude this. Again, we can easily cultivate the cataleptic *flexibilitas cerea* in an ordinary hypnotic state.

It would appear, then, that it is very doubtful if any value can be placed on the classification of Charcot.

Legal questions, as might readily be imagined, have arisen in connection with these acquisitions to our knowledge of the influence of one person over another. They need only be briefly dwelt upon. In the first place, a person who has been hypnotised may falsely accuse the hypnotiser of unlawful acts, or of inciting him to do unlawful acts. This danger should always be avoided by first gaining the person's consent to be hypnotised, and by always having a competent witness present.

Supposing such an accusation were made, if the person were hypnotised by the previous hypnotiser or by another, what had happened in a former hypnosis could readily be elicited, the hypnotised person not being capable of distorting the truth; for the absence of voluntary control over mental operations is precisely the characteristic of the hypnotic state.

In the second place, hypnotic suggestion may be made use of for unlawful ends; thus crimes have been committed by persons as the result of post-hypnotic suggestion by another. It may be most difficult to discover this; the following considerations, however, will generally be of assistance in coming to a correct conclusion. If the suggestion had been given in the pre-somnambulistic stage, the person will remember it; if in the deeper stage, not. Now the number of persons who pass, the first time they are hypnotised, into a sufficiently deep somnambulism for the suggestion of a crime to be accepted is very small; so that generally some evidence could be obtained of the person having been hypnotised several times. Again, a post-hypnotic act, if other than some simple automatic movement, will be done in either a hypnotic state or consciously: if in the former, the person will not remember what he did, and witnesses will probably have noticed some change suddenly taking place in his demeanour; if in the latter state, the person will recognise some impulsive idea which he could not resist (though ignorant of its origin), and this will be the greater, the greater the dissonance between his character and the act. And, in any of these cases, if the person be hypnotised, the events of former hypnotic states will be remembered.

It would appear, then, that the only really difficult case would be when the hypnotiser had not merely given the post-hypnotic suggestion of the crimes, but also the suggestion that no one but he could hypnotise the person. It is, however, probable that the exclusive influence of one hypnotiser over a subject is not permanent, so that after a little time a skilful hypnotiser would be successful in re-hypnotising the subject.

With these few remarks on the legal aspect of the question, which is of much greater importance on the Continent than in England, I must bring this paper to a close.

It has only been possible to sketch the main outlines of our knowledge of hypnotism, to give an account of the more certain facts and of the theories which appear to afford us, in the present state of our knowledge, the best explanation of these.

NOTE ON CLASSIFICATION OF HALLUCINATIONS OF SIGHT.

	Involving retina.	Not involving retina.	
		With *point de repère.*	Without *point de repère.*
Characteristics.	i. Not doubled by pressure on one eye. ii. Moves with eyes. iii. Projected on looking at a dark ground. iv. Covers external objects.	i. Doubled by pressure on one eye. ii. Does not move with eyes. iii. Confounded with external object.	i. Not doubled by pressure on one eye. ii. Does not move with eyes. iii. May or may not be projected, but same whether eyes open or shut.
Physiology.	The nervous change begins at the retina and passes to the brain; the commonest example is an "after-image."	The cerebral nervous change does not owe its origin to an impulse passing up from the retina; it may take place, for instance, when the optic nerves are atrophied.	

Language and Race.

By ARTHUR B. PROWSE, M.D. Lond., F.R.C.S. Eng.

Read April 2nd, 1891.

THE subject I have chosen is one of very great interest and of far-reaching import, though to many it may at first sight seem neither the one nor the other. It chiefly concerns language in its relation to the various races of Man.

When we observe a community of insects, such as *ants*, carrying out carefully planned works, and even concerted attacks on other communities, it is plain that individual members must have a means of communicating their intentions and feelings to others. With them, probably, the sense of touch is the medium. In the same way birds use various sounds—at one time they warn their companions of danger, at another time a different sound will make known the finding of something good for food.

Those of us who keep pets soon learn to recognise the various ways in which they express their mental states; *e.g.* it is easy to know whether a dog's bark means he is pleased, or angry, or in want of something definite. This faculty of barking, however, is not natural to dogs, but has been developed since they became the friends and companions of man;

and it is lost again by isolation in uninhabited islands. It is interesting to find that the young of such isolated animals manifest no tendency to bark, in spite of the hereditary influence which might be expected after centuries of practice of the habit; but the natural sounds—howling, snarling, etc.—are still used. As regards monkeys, the sounds they utter are on the same level as those of the dog. Some naturalists, Pruner Bey for example, have stated that the vocal organs of apes are not adapted to the formation of articulate sounds; but this seems to be a mistake. It is the absence of a certain mental power, and of the control it exerts, which alone makes the difference. Darwin, in his *Descent of Man* (vol. i., p. 53), gives, as an example of the power of vocal articulation, the case of certain monkeys in Paraguay which utter six distinct sounds, each of which produces a definite effect upon the other monkeys; but I cannot see that this power is different *in kind* from that possessed by birds or dogs.

The speech of man is divided from the sounds of intelligence used by animals, not only by a far wider range of communication, but also by the power of making known to others mental perceptions, and, further than this, cognitions which soar high above and beyond the reach of the mental powers of animals. If the bark of the dog be the first attempt at speech, it is a failure, in that a special sound is not even assigned to any person in particular. Directly a child consciously calls its father or mother, true speech has begun. To the human race alone belongs the divine gift of those mental powers which have given birth to speech. Looks and modulations of voice seem to agree in all nations, gestures only in part, thus forming the bridge by which we may pass over into spoken language—the dividing element in human history. The first three are used by the lower animals as well as man. Articulate language alone draws an impassable barrier between us and the beasts.

The speech of different nations and communities shows almost endless variety. How far are we justified in assuming that the use of similar or cognate languages proves a near blood-relationship of the peoples using those languages? And, again, may we conclude that the use of very dissimilar tongues by different nations is sufficient proof that they cannot be closely allied racially? In other words, is language a sure guide to race?

The evidence bearing upon this question has grown very quickly the last few years, and its mass is now so great that it will be only possible in the brief space of an hour to give a mere sketch of it.

The chief point at issue will perhaps be made more clear by the following assertion: "The classification comprehended in the terms Aryan, Semitic, Turanian, etc., is in point of fact one of *languages* only; but the popular delusion is that it is a well-founded and scientific classification of the *races* of man." I call it a "popular" delusion because it still has a firm hold upon the minds of a large majority of those who take any interest at all in racial questions. Comparatively few, outside a small circle of scientists, have as yet recognised it as a fallacy; and indeed it is not many years since philologists and ethnologists themselves taught it as a truth, to doubt which was rank heresy in science. Man is indeed very liable to err: "most ignorant of what he's most assured."

When the newly-born science of Comparative Philology, about fifty-five years ago, was able to show that most European languages and some Asiatic were so related that logical deduction proved they must have sprung from one mother-tongue, a further deduction, by no means logical, was drawn, and men asserted that the speakers of these languages must be all closely related by blood.

The authority of Professor Max Müller perhaps more than that of any other writer led to the popular acceptance of this theory, which the growth of knowledge has now proved to be a mistake. Nevertheless, even now we find writers of repute, such as Professor Rawlinson, quoting Max Müller's teachings of twenty to thirty years ago upon this very question, and speaking of them as the "result of advanced modern inductive science" which has "proved beyond all reasonable doubt" a close blood-relationship of the nations which speak Aryan languages. After the needle of scientific teaching had thus deviated far from the pole of truth under the influence of unbalanced philological theory, the anthropologists began to assert themselves; and at the present time it seems as though the needle has swung back too far, and has reached a point on the other side almost as far from the line of truth as the position it previously occupied. The French anthropologist, Broca, says: "The ethnological value of comparative philology is extremely small. Indeed, it is apt to be misleading rather than otherwise." This is going a little too far.

The fact is, if we wish to advance our knowledge of truth we must be content to learn slowly, patiently sifting the evidence afforded by each branch of science, and controlling the deductions of one by those of other branches, avoiding positions of unstable equilibrium such as must result from attaching undue importance to theories which promise support to opinions based, to a large extent perhaps, upon individual mental bias.

I propose to consider, in the first place, the evidence afforded by the study of language; and then, more briefly, to touch upon certain anthropological facts.

What, then, is Language? It is the outward expression of conscious thought, and equally the expression of will, by means of sounds uttered by the organs of voice; the sounds being arranged or articulated into groups called *Sentences*. A sentence implies a mental judgment, a limitation of one idea by another; the ideas being often represented by *Words*. If it be asked, What is a word? the only comprehensive definition is, "meaning combined with form."

Language is based upon the *sentence*, not upon the isolated word. Waitz truly said, "We do not think in words, but in sentences; hence we may assert that a living language consists of sentences, not of words." It is the conception of the sentence, therefore, wherein languages will resemble, or differ from, one another. In Chinese the sentence is summed up in a single word, and the mind has not yet clearly marked off its several parts. This next stage has been done in the group of languages called Turanian, but the sentence is of the simplest character, each portion having the same force. Only when we come to such languages as are comprised in the Semitic and Aryan groups do we find that the parts of the sentence are duly subordinated, and that co-ordination of function is replaced by a fitting correlation. Thus we get the three primary groups into which languages have been arranged (*see* Table I.)—the Isolating, the Agglutinate, and the Inflectional. Chinese is a good example of the first, Turkish and Finnish of the second, Arabic and German of the third.

These classes, however, are not limited by any very rigid bounds, for in different parts of the world there are tongues which partake in a greater or less degree of the characters of two of the groups. Thus, Japanese and Corean have characters which place them on the borderland between the Chinese and the Altaic group of Agglutinate tongues; and,

TABLE I.—TYPES OF LANGUAGE.

ISOLATING.		Polysynthetic.	AGGLUTINATE.		Incorporative			INFLECTIONAL.			
Chinese. Anamese. Siamese. Burmese. Thibetan.	Japanese. Corean.	American.	Eskimo. Namollo.	ALTAIC GROUP. (Tungusian.) (Mongolian.) (Turkish-Tatar.) Samoyedian. UGRIAN GROUP. (Lapp.) (Finnish.) (Mordvinian.) (Votiak.) (Vogulian.) Etc.	Accadian. Magyar. Basque.	HAMITIC GROUP. (OldEgyptian.) (Coptic.) (Berber.) Etc.	Bantu. Koi-Koin.	SEMITIC GROUP. *North.* (Assyrio-Babylonian.) (Aramean.) (Hebrew.) (Canaanitish.) (Phœnician.) (Punic.) *South.* (Arabic.) (Ehkyly.) (Amharic.) Etc.	ARYAN GROUP. *West.* Slavonic. Lettic. Teutonic: (Germanic.) (Scandinavian.) Keltic: (Erse, Gaelic, Manx.) (Kymric, Cornish, Breton.)	Albanian. Hellenic. Armenic. Italic.	*East.* Indic: (Sanskrit.) (Bengali.) (Urdu.) Iranian: (Zend.) (Persian.) (Pushtoo.) (Kurdish.) (Ossetic.) Etc.
		Australian. Papuan.	Malayo-Polynesian, Dravidian (?).						Dravidian (?). (Tamil.) (Telugu.) (Canarese.) (Santal.) Etc.		

as a further difference, Chinese is monosyllabic, whereas they are polysyllabic.

Again, the Hamitic group of tongues, which includes the Ancient Egyptian, the Coptic, the Berber, etc., has considerable affinity with the Semitic group, and at the same time with the old Accadian class of the Agglutinate languages. The language of the Basques, viz., Euskara, while having many resemblances to the Ugro-Altaic tongues, is also inflected to a very noteworthy degree. The Dravidian group of languages, spoken in South India, including Tamil, Telugu, Santal, etc., is in a similar condition; for while some philologists have classed it with the inflectional Aryan, others have included it in the Agglutinate group. A few days ago I asked a friend, now living in Clifton, who was in South India for many years, and who is now examiner in Tamil for the Civil Service, his view of the question, and he says it is a "very largely inflected" language, and inclines to the opinion that it should be classed with the Aryan group.

Not only are there intermediate forms between the three chief groups, but different members of each group contrast in character very markedly with each other. Thus the Agglutinate group includes two sub-groups—the Polysynthetic and the Incorporative—the former of which comprises the aboriginal languages of North and South America. In them the parts of the sentence are fused together into a long compound; the several words of which it is built up being abbreviated or cut down to root-forms, by the same kind of accentual instinct which makes the French drop their final letters in pronunciation, though each fragment still remains an independent word of equal force with the rest.

Thus, in Mexican, a *priest* is addressed as *notlazomahuizteopixcatâtzin*, made up of *no—tlazontli—mahuiztic—teopixqui—tatli*, *i.e.*, my esteemed revered god-keeper father and in Delaware, *kuligatchis* signifies, "Give me your pretty little paw," from *k* (2nd person particle pronoun) *wulit*, pretty,—*wichgat*, paw,—*shiss*, littleness.

In the Incorporating languages the objective pronoun is inserted into the verbal form, and a few words are loosely attached to the verbal root, unimpaired in form, and of independent power. The old (pre-Babylonian) Accadian tongue of the lower Euphrates Valley is a good example of this: thus, from *in-bat*, he opened, was formed *in-nin-bat*, he opened it. This plan occurs in Magyar, to some extent, and also in Basque, and the Mordvinian dialect of North Russia. From one point of view it may be truly said that there is much more difference between Incorporation and Polysynthetism than between Incorporation and Inflection.

A consideration of these phenomena of gradation between extreme types of language, as well as of certain other philological observations, led to the framing of a theory which a short time ago held universal sway, and even now has plenty of supporters. I mean the idea that the Inflectional languages have passed through Agglutinate and Isolating stages. But although the three classes of language trespass occasionally on one another's ground, and partake in some measure of the characteristics which distinguish each, this is merely an illustration of the principle, here as elsewhere in nature, that one variety or family passes gradually into another, so that the boundary line between them cannot be sharply defined.

"This, however, does not affect the general character of the language; although those who look to the individual *word*—the product of the later age of reflection, analysis, or literature—instead of to the *sentence* may be puzzled how to distinguish between the three great classes of speech. The existence of these three classes, however, is a fact; but it is equally a fact that, in each of these, phenomena occur which characterise the other two. The advocates of the Development theory would do well to consider this, and explain how it is that, in spite of the occurrence of inflectional phenomena, the Agglutinate group has (as far back as the evidence at our disposal goes) always been agglutinative, and the Isolating group, isolating. Chinese possesses forms which may be classed as agglutinative, and yet throughout the whole course of its long historical existence it has continued as true to its primitive type as the Isolating dialects of barbarous Taic tribes. The Finnic verb may be called inflectional, but for all that the Finnic group is not less agglutinative than the Accadian of 4,000 years ago. Aryan has always been inflectional, so far back as our veritable facts allow us to go; and to assign to it a preceding era of agglutination is an hypothesis which has history against it" (Sayce). That a language remains true to its type is the teaching of the known facts of philology.

Seeing, then, that there are these significant groups of languages, the question naturally arises, Do the main divisions of the human race run parallel with them? On the threshold of this inquiry we meet with a great difficulty,—I mean the extraordinary variations in the mode of classification of races which have been adopted by different anthropologists. It has been well remarked by Peschel, "No one can feel more forcibly the weakness of the opinion which holds to the immutability of racial characters than one who has endeavoured to describe various nations, for no single characteristic is strictly the exclusive possession of any race of men, but each loses itself by imperceptible gradations. If it were easy to draw the line between the various races, anthropologists would not so far differ from one another, that one feels himself obliged to separate mankind into *two*, another into *one hundred and fifty*, species, races, or families."

And again, "We must needs confess that neither the shape of the skull nor any other portion of the skeleton has afforded sufficiently comprehensive distinguishing marks of the human races; that the colour of the skin likewise displays only various gradations of darkness, and that the hair alone comes to the aid of our systematic attempts, and even this not always, and never with sufficient decisiveness. Who then can presume to talk of the immutability of racial types? To base a classification of the human race on the character of the hair only, as Haeckel has done, was a hazardous venture, and could but end as all other artificial systems have ended. In the separation of the Hottentots from the Bantu negroes, this system has led to errors; and the combination of Australian aborigines, as a so-called

TABLE II.—RACE GROUPS.

	Black.	White.	Yellow.
Cephalic Index ..	70–75	75–84	81–91.
Orbital Index ...	79–85	83–85	82–95.
Cranial Capacity (in cubic inches)	African, 86·2 Australian, 81·7	92·1	Asiatic, 88·7. American, 89.
Hair { Section ... State	Flattened Frizzled or Woolly	Oval Somewhat curly	Circular. Straight.
(Summary) ...	Long heads Long orbits Flat hair		Round heads. Round orbits. Round hair.
	1. Australians and Tasmanians 2. Papuans. 3. Dravida. 4. Negroes. 5. Hottentots and Bushmen.	6. Mediterranean Nations. (*a*) Hamites. (*b*) Semites. (*c*) Indo-Europeans.	7. Mongoloid Nations. (*a*) Asiatic Group. (*b*) Malayo-Polynesian. (*c*) American aborigines.

straight-haired people, with the Mongols, is due to ignorance of facts."

I shall to-night adopt what appears to me the most satisfactory provisional grouping (see Table II.). It will be seen from the table that in most of the tests the *White* group is intermediate between the other two, but that in cubic capacity of skull it exceeds them.

As to the types of language employed by the different race-groups, the *Yellow* races use both isolating and agglutinate forms: the American branches being marked out clearly by the polysynthetic character of their tongues.

The *White* races use mainly highly inflected languages of two marked types—Semitic and Aryan; while the tongues of the Hamitic branch of the Mediterranean group, which in many respects is allied by physical characters to the more southerly African races, have marked affinities with the incorporative branch of Agglutinate speech, and also with the Semitic branch of inflectional speech. With regard to the racial characters of these north African so-called Hamitic tribes, it has been well remarked by Müzinger, Hartmann, and others, that on close observation the candid traveller no longer knows where the true negro begins, and his belief in the absolute distinction of race diminishes more and more.

As to the languages of the *Black* races there is also great variation in type; the Australian and Papuan are mainly agglutinate; the Dravida tongues are of agglutinate type, but at the same time greatly inflected; while the Bantu negroes and the Hottentots, or Koi-Koin, speak tongues of a peculiar inflectional character.

Thus we see that the type of language used is not altogether a reliable guide in the determination of racial affinity. Race and language, even as regards their broad divisions, do not run parallel.

Here perhaps is the most suitable place to mention the fact that in all languages, and most markedly in inflectional ones, there are two stages—a Synthetic and an Analytic. First there is a tendency to the building up of words from simpler forms: this is most marked in inflectional tongues, which express different relations, by additions or changes of sounds, within or at the end of the words. But most primitive grammars, such as the agglutinate Eskimo, show very considerable synthetic complexity. As the language grows older, there follows a tendency for the additions to become broken down and wasted; this is the Analytic stage, in which the attenuated compounds are used to express singly, by the aid of position, the various relations into which a sentence may be resolved, and the words tend to become monosyllabic. At first sight it might be thought that the result of analysis would be to reduce an *inflectional* to the condition of an *isolating* tongue; but this is not so. Perhaps the best illustration of the difference between the analytical and isolating forms is a sentence taken from Schleicher's "Languages of Europe":—"The king spoke: O Sage! Since thou dost not count a thousand miles far to come, wilt thou not also have brought something for the welfare of my kingdom?" This, when expressed in Chinese, presents the following unintelligible form:—"King, speak: Sage! Not for a thousand mile and come; also will have use gain me kingdom, hey?" When an inflectional language has become analytic, the relations of the various words in a sentence is expressed chiefly by the aid of little words, such as *to*, *of*, *for*, etc.

Up to about 1100 A.D. English was a synthetic language, but since then it has been gradually becoming analytic; and this character it now possesses in a greater degree than any other tongue. Persian, French, and Danish are also mainly analytic in character. The simplification in grammar thus effected is highly important; and it is the chief reason why English is the easiest of all languages for a foreigner to learn to *speak.* It would be equally easy to *write* it, if only we had returned to the true mode of spelling, *i.e.* the phonetic.

In studying a language we have to consider its *vocabulary*, *grammar*, *syntax*, and *idioms.*

The Vocabulary of a savage is never large. A comparatively few words suffice to express the workings of his mind; but in proportion as he adopts civilised habits and ideas does his stock of words become larger. Extensive social and commercial relationships with other peoples also favour very greatly the adoption of new words; and an analytic language, like ours, borrows far more readily than a synthetic one does. Cases are known in which almost the whole vocabulary of a tribe or nation has been derived from abroad. These remarks apply to all languages, but the vocabularies of some are held far more tenaciously than those of others. The Aryan family especially is marked by much less tendency to change, than the other groups, in both lexicon and grammar.

The Grammar is a far more important item in a language than its words for determining its affinities. In comparing languages, we must begin with the nature of the sentence, and then proceed to the grammar, the idioms, and lastly the vocabulary. However great the change in this last, the manner in which the mind views objects and their relations —that is to say, the structure and grammar of the language —remains, as a rule, unaltered. When, as is not unfrequently the case among savage tribes, two neighbouring villages become nearly unintelligible to one another, it is on account of changes in pronunciation, in idiom, and in vocabulary, not in the grammatical forms. Seeing then that grammar is so persistent, the questions arise: (1) Is it possible for one tongue to assimilate a portion of the grammar of another, so that a hybrid shall result? and (2) Can a race adopt an entirely new grammar?

With regard to the first point, the possibility used to be asserted, and was unquestioned; but further research has modified this belief. The proximity of two languages implies that a certain number of the population are bilingual; and where this is the case to any large extent, the idioms of the two will often be exchanged; and with them it is natural to suppose that an opening will be made for the introduction of new grammatical forms. The use of the genitive and dative of the personal pronouns in English ("*of me*" and "*to me*") in place of the Anglo-Saxon *min* and *me*, seems to have been due to the Norman influence; the Normans themselves having previously adopted the change from the conquered French. Persian has adopted the Semitic order of words, which is so unlike the general structure of the Aryan group,—saying, for instance, *dil-i-măn*, "heart of me," for "my heart," and *dăst-i-'Umăr*, "hand of Omar." Conversely the Hararite is able to reverse the Semitic order, and adopt a non-Semitic idiom by writing *ámir askir*, instead of *askar ámir*, for "the Emir's army." The same sub-Semitic dialect shows the phenomenon of a grammar which is decidedly Semitic in its main features, but which makes use of post-positions.

Persian, which contains a large Semitic word-element, has even gone so far as to form one of its plurals by means of the Arabic feminine plural in *āt* or *jāt*. Practically, however, this plural is confined to the imported Arabic words, and so is a similar instance to that in our own tongue, when we use Latin plural endings for adopted Latin words, such as *termini*, from *terminus*.

All the foregoing instances are of the nature of small and minor exceptions to a general rule. Two nations may have started from the same source with a common stock of ideas, and a common psychological tendency, yet in so far as their experiences have been different the formative elements of their languages will be different, and not easily interchangeable. The grammar of pigeon-English is not English, but Chinese; the grammar of Persian remains Aryan.

There is, indeed, one case by which at first sight this general rule is flatly contradicted. Certain inscriptions have been found in Persia written in what seem to have been two dialects, usually termed Chaldæo-Pehlevi and Sassanian-Pehlevi.

This latter is a most heterogeneous mixture of Aryan and Semitic: grammar as well as vocabulary. There is a fusion of the Aryan and Semitic order of words, and also of the inflections. If this dialect were ever a widely spoken one, it would be fatal to the general rule mentioned above; but further study seems to show it was not a spoken tongue, or, at all events, not beyond a select court or priestly circle.

Until, therefore, a more convincing example can be brought forwards, we must abide by the belief that the grammar of a nation will remain native, unless wholly supplanted by another; although under certain conditions foreign influences may effect the adaptation of existing formative tendencies to new uses. Thus, Coptic, which was formerly an affix-language, like old Egyptian, has become a prefix-language, resembling in this respect the Berber and other sub-Semitic dialects of North Africa.

With regard to the question, "Can a race adopt an entirely new grammar?" it must be answered in the affirmative, for numerous examples exist.

Intimately connected with the grammar is the Phonology of a language. The modifying influence in pronunciation of one dialect or tongue upon another is often very marked in the lapse of years. A very good example is the adoption by the Kafirs (or Bantu negroes) of the peculiar clicking sounds of the Hottentot (or Koi-Koin) tongue. This is the more strange, because the sounds are difficult to produce; and the superiority of the borrowing race is patent to all.

The Norman Conquest had a great deal to do with the softening of the gutturals of the Anglo-Saxon.

A mixed race inherits the phonetic capabilities of its parents, and we acquire our pronunciation almost entirely in the mimetic days of childhood.

As regards the importance of rules of Syntax, there is very great variety in different tongues. The Chinese follow the strictest precepts in regard to it, and their rules are sufficient to give perfect clearness to a language consisting entirely of monosyllabic roots. They may therefore claim to have supplied every requisite for the interchange of thought by this means. Syntax is to them of prime importance, for position alone decides whether a word is used as a verb, a substantive, an adjective, an adverb, or a preposition. Their use of intonation and accent is also a very great assistance in conversation.

As a contrast to Chinese, we may take Latin, where no special arrangement of words is prescribed in the structure of a sentence, and the position of the parts of speech is left very much to the artistic feeling of the speaker. As to the position of the verb and objective noun in a sentence, it is to be noted that though the usual place of the verb in Latin is at the end of the clause, and that this is an almost absolute rule in German and Dutch, the Romance languages place the verb before the objective case.

English follows the same order, though poetry or a poetical style may employ a contrary arrangement without fear of obscuring the meaning. This order is found only in the analytic stage of Aryan speech, that is, in its most modern form; while the arrangement which sets the verb at the end becomes more and more universal the further back we go. Before the Norman Conquest we arranged our words in a sentence just as the Germans do at the present day, viz.: (1) in a subordinate sentence the verb came at the end, and (2) the auxiliary was separated from its verb. Both of these habits have since been changed; so that now there is a very great contrast between English and German.

This is of course well known; but the point is so well put in the following extract from the London *Daily Telegraph* of August 1st, 1890, that I have been tempted to transcribe it: "To a person thoroughly versed in both languages, it is difficult to decide which is the funnier—Anglicised German, or Germanised English. Compound auxiliaries in the infinitive, such as 'to become to be,' and 'to have to shall,' which are perfectly correct and natural in High Dutch, sound strange and comical in the British ear. Yet how else should an average German schoolboy, of from ten to twelve years of age, writing English perforce, terminate the majority of his sentences? Scarcely less mirthful would be the English boy's German, with verbs well to the front, after our insular manner, instead of lingering jointly and collectively in the rear of each parenthetical phrase, as is their wont when flowing freely from the pen of a born Teuton. Although the greater number of their root-words—well nigh all the monosyllabic ones, indeed—are nearly identical, yet the two languages differ from one another to a positively distracting extent in grammatical construction and verbal arrangement. They are both, moreover, vigorously idiomatic; and the individuality of each is so distinct from that of the other as constantly to render their literal inter-translation impossible. German colloquial idioms may be paraphrased into English, and *vice versâ;* to render them word for word is to deprive them not only of point and force, but of intelligibility. Men of ripe scholarship, who may be said to have thoroughly mastered both languages, are not infrequently perplexed by the apparent inadequacy of the one to reproduce the inner feeling or sentiment, as well as the textual meaning or significance of the other."

With regard to Idioms, which may be defined as "modes of expression peculiar to a language," I shall say no more than that they may be borrowed by one tongue from another belonging to the same great group; but that if the languages in contact belong to different types—Isolating, Agglutinate, Inflectional—such exchanges do not occur. Thus the Finnic idioms are still agglutinative, although the verbal forms are inflectional.

To proceed,—we find that, as a rule, when two or more peoples speaking different dialects are fused into one nation, the future spoken language will in the main be that of the more numerous race. A good example of this is the case of the Norman-French dialect, which gradually disappeared before the Anglo-Saxon, so that at the present day our *spoken* language is mainly a derivative of the latter.

Professor Meiklejohn says that though only about one-third of the 100,000 *dictionary* words are of Anglo-Saxon origin, yet "the spoken social language is almost entirely Anglo-Saxon; it borrows only here and there from foreign tongues."

It has been found that 96 per cent. of the words in St. John's Gospel (A.V.) are pure English (A.-S.): the proportion in Shakspere is 90 or 91; in Mrs. Browning's "Cry of the Children," 92; in the early part of Tennyson's "In Memoriam," 89; in Macaulay's "Essay on Lord Bacon," 75 in the preface to Johnson's Dictionary, 72; and in Gibbon's "Decline and Fall of the Roman Empire" (I. vii.), 70. As to the kind or quality of the Anglo-Saxon element, we find that all the grammar and grammatical inflections are English: the auxiliary verbs, the prepositions, the conjunctions, and, in a word, all that goes to make up the framework of the language. The prefixes and affixes in most frequent use are English, *i.e.* the prefixes and affixes for nouns, verbs, adjectives, and adverbs. The words that relate to home-life, to the works of nature, to the ordinary kinds of labour, and to the body and its actions, are nearly all pure English. The same is the case with most monosyllables; and, in general, with all the literature of country sayings and proverbs.

When speaking of dialects just now, I omitted to define the term. For all practical purposes we may say that a dialect is a "little language," and, conversely, a language is a "big dialect." The difference is one of degree only.

Civilisation tends to produce unity of dialects as well as of societies and customs. On the other hand, savage societies and their languages are in a constant state of change; tribal distinctions tend to multiply, and numerous dialects arise. The speech of barbarous tribes is, in fact, perpetually changing; and nothing is really harder than to keep a language from rapidly altering where it is not protected by habits of settled life.

We find great diversity in even very small areas. The most striking example, perhaps, which occurred in recent years was in Tasmania, where, with a very small native population (then only fifty), there were no less than four dialects, each with a different word for *ear*, *eye*, *head*, and other equally common words.

Pliny tells us that in Colchis there were more than 300 dialects. In 1630, Sagard found that among the Hurons of North America there were hardly two villages with the same speech; while each of the numerous dialects was changing from year to year. Captain Gordon records the fact that some of the Manipuran dialects were spoken by no more than thirty or forty families; and the differences between them were so great, that the speech of one group of families was nearly unintelligible to the other groups around.

As civilisation advances, the improved social conditions tend to break down the differences, and a common medium of intercourse spreads over large areas.

Of the larger subdivisions of language, we are naturally most concerned with the Semitic and Aryan groups. They are both of the inflectional type; but the character of their inflection is very dissimilar. The Semitic is a small and very compact family, and its members do not differ more among themselves than do the Romance languages of Western Europe. There is far greater variety in the Aryan family; but, nevertheless, if any one thing distinguishes a member of it, it is the persistency of type, the general fixity of grammatical form, and the common residuum of roots, which at once enable its character to be seen.

In both Aryan and Semitic the inflectional defining element is most firmly united with the principal root, but the mode of union is widely different.

The Semitic tongues are known by the fact that their radicals, or roots, consist of three consonants; though, in some cases, the third is often barely represented. Vowels which modify the meaning are placed before, between, or after these consonants. This may be shown by an example often used. Arabic uses a group of three consonants—q, t, l—for everything which has to do with the shedding of human blood. Thence are formed—*qatala*, he kills; *qutila*, he was killed; *qutilu*, they were killed; *uqtul*, to to kill; *iqtal*, to cause killing; *qatil*, killing; *qitl*, enemy; *qutl*, murderous, etc. In the verb, the *middle* vowel bestows a transitive or intransitive meaning. By the vowel of the *first* syllable of the radical the active (a) is distinguished from the passive (u); and the vowel of the *last* syllable denotes the mood, *u* expressing the indicative, *a* the subjunctive; while in the imperative the vowel disappears. The other changes of the verb are effected by prefixes and suffixes, which also have a modifying phonetic influence on the vowels of the syllables to which they are prefixed or appended. Terminal syllables distinguish the singular and plural, as well as the three cases—nominative, genitive, and accusative.

An equal, or, as many think, a higher, rank is occupied by the Aryan tongues. They have an advantage over the Semitic in that they recognise three, instead of two, genders,—or rather, sexual and sexless objects; but this superiority has been again partly lost in the course of time. Armenian ignores all distinction of gender. Another distinction is that the Aryan tongues alone possess the verb *to be*; so that in a Semitic tongue the idea of the graciousness of God cannot be expressed by the words, "God *is* gracious," and it is necessary to use a phrase such as "God, the gracious," or "God, He the gracious."

In the Aryan group the formation of secondary words from the roots originally took place by the addition of a post-fix; while prefixes were only sparingly used, and this chiefly in negatives with *un*, as in *ungrateful*; or with *a*, as in *atheism.* Antecedent prepositions, such as in *forecast*, *outspread*, *overthrow*, were also used. German has many prefixes, the original meaning of which has become lost, as in *be*schreiben (to describe), *er*gründen (to fathom), *zer*fleischen (to lacerate), *ver*kaufen (to sell), etc.

But in more modern times a deterioration of morphological structure has taken place, especially in Germanic languages. When the inflectional terminations had become worn down, or wasted, beyond recognition, the mind (as a compensation for the loss of significant affixes) seized on a medium for the definition of meaning, which had before been only casual and incidental, namely, the metamorphosis of vowel-sounds; as, for example, in *woman* and *women*, in *give* and *gave*. Thus was acquired the use of a significant change of vowel-sounds very like that in the Semitic tongues. It is quite possible that the latter owe their symbolical use of vowels to the same cause; and if further research should show this was the case, it will be a most important fact.

Turning now from linguistic details for a time, we find that two inquiries have excited much interest for many years past: (1st) Who were the original speakers of the parent tongue of the Aryan group? and (2nd) In what part of the world were they when this mother-tongue was used? This latter inquiry really preceded the former, but its secondary position at present is due to the recognition of the fact, by all philologists and ethnologists, that language is not a sure guide to race, and that similarity or even practical identity of languages only proves the social contact of the peoples using them at some previous stage of their history; and it is seen that if the first question can be satisfactorily answered, a reply to the second will have been brought more within the range of probability.

For a long time it was believed that the original home of Aryan mother-tongue had been undoubtedly found in Central Asia, in the region of the Hindu Kush mountains, and the elevated tableland of Pamir; but of late years an almost universal change of scientific opinion has been brought about, and some part of Northern Europe has seemed to many to have far stronger claims.

It is quite out of the question to-night to do more than mention the result of anthropological inquiries as to who were the original speakers of the mother-Aryan. In Europe, excluding the more easterly parts, there is evidence of the presence of four definite racial types (see Table III.),—(1) The Scandinavian or Teutonic, (2) the Iberian or Aquitanian, (3) the Ligurian or true Keltic, and (4) the Kymric or Belgic. French and German scholars hold different opinions as to which of these represents the original stock which used the Aryan mother-tongue. The question has been debated with much acrimony. German writers, *e.g.* Pösche, Penka, Hehn, and Lindenschmidt, have contended that the physical type of the primitive Aryans was that of the north Germans,—a tall, fair, blue-eyed, dolichocephalic race. On the other hand, Frenchmen, such as Chavée, De Mortillet, and Ujfalvy, have maintained that the primitive Aryans were brachycephalic, and were the direct ancestors of the Gauls. The Germans claim the primitive Aryans as typical Germans who Aryanized the French, while the latter claim them as typical Frenchmen who Aryanized the Germans. Both parties maintain that their own ancestors were the pure noble race of Aryan conquerors, and that their hereditary foes belong to a conquered and enslaved race of aboriginal savages, who received the germs of civilisation from their hereditary superiors. Almost as much can be said for both views; but, on the whole, the evidence—philological, anthropological, archæological, and historical—seems to incline rather to the brachycephalic

Table III.—EUROPEAN RACE TYPES.

Dolichocephalic.		Brachycephalic.	
Tall, Prognathous, Fair.	Short, Orthognathous, Dark.		Tall, Prognathous, Florid.
Scandinavian, or Teutonic.	Iberian, or Aquitanian.	Ligurian, or Keltic.	Kymric, or Belgic.
Cephalic Index =70–73. 5 ft. 10 in. Fair hair, blue eyes, white skin.	Cephalic Index =71–74. 5 ft. 4 in. Swarthy complexion.	Cephalic Index =84. 5 ft. 3 in. Black hair.	Cephalic Index =81. 5 ft. 8 in. Florid skin, light eyes, rufous hair.
"Row graves." "Kitchen-Middens."	"Long Barrows." Caves in France, Spain, Algeria, Teneriffe, Wales, etc.	"Dolmens" of Central France. Caves in Belgium.	"Round Barrows." Belgian, French, and Danish graves.
Canstadt. Engis. Hohberg. Lowest Grenelle skulls.	Cro-Magnon. Middle Grenelle skulls.	Disentis. Furfooz. Trou de Frontal. Upper Grenelle skulls.	Sion. Cowlam. Gristhorpe.
Vandals (?) Franks (?) Alemanni (?) Burgundians (?)	Aquitani (Cæsar). Silures (Tacitus). Firbolg, in Ireland. Guanches, in Teneriffe.	Keltæ (Cæsar) of Central Gaul, and Gallia Cisalpina.	Belgæ (Cæsar). Galatians (Diod. Siculus). Caledonians (Tacitus). "Tuatha de Danan," in Ireland.
Swedes. Frisians. North Germans.	Some W. Irish. Some S. Welsh. Some Hebrides clans. Spanish Basques. Corsicans. South Italians. Berbers.	Auvergnats. Savoyards. Swiss. A few Bretons. [No evidence of this type in the British Islands.]	Danes. Some Irish (Cavan).

Kymric type being that of the original Aryan-speaking race.

The mistake of jumping to conclusions, and of generalising from insufficient data, is well illustrated by the complete collapse of the theory, formerly held by all students of mankind, that language was an unerring guide to racial affinity.

Much of what I have already brought to your notice this evening has tended to negative this theory; but I think it well to furnish more evidence, taken from a paper published in the *Journal of the Anthropological Institute*, by Professor A. H. Sayce, of Oxford:—"The assertion that language is a sure and certain test of race is one than which there is none more readily to be confronted with history; and, when so confronted, more clearly proved to be false. Language is no physiological necessity; it is not one of those physical marks, such as colour of skin or shape of skull, which are inseparable from an individual. But though language is no mark of race, it is a mark of social contact or society. The language we speak is not implanted in us at our birth. The child has painfully and slowly to learn his native tongue, though doubtless he inherits a certain aptitude for doing so. If he is born in England, it is English he learns; if in France, French. If two or more languages are spoken by those about him, he is likely to acquire these languages more or less perfectly, according to the degree in which he comes into social contact with those who speak them.

"Languages once known can be entirely forgotten, and foreign ones become as familiar as though they were native. Children whose language was Hindustani have forgotten it utterly after a short residence in England, and it is often difficult to reproduce a sound which was constantly on the lips in childhood." What holds good of the individual, holds equally good of the community; but we must not fall into the mistake of confusing *community* with *race*, for the same race may be divided into a multitude of communities, each separate and independent, and with special characteristics of its own as to language, customs, etc.

"A society may continue to exist, thanks to its customs or the influence of race, while the language it spoke has disappeared, through the daily need of communication with other and more powerful societies speaking a different language. Thus, Jewish societies exist all the world over as separate societies with peculiar rites and customs, and apart from any question of race; and yet their language is for the most part that of the people among whom they are settled." We cannot be sure that the same event has not befallen other races; for if it is possible with one, it must be with others also.

"Keltic is extinct among the Kelts of Cornwall and the Isle of Man, and the same fate seems to threaten the other Keltic dialects of Great Britain and France. Slavonic has disappeared from Prussia; and Basque alone is left of the pre-Keltic languages of Western Europe. Keltic itself had to make way for Latin in Gaul and Spain, like Punic in Africa; and the Normans first lost their mother-tongue in Normandy, and then their new tongue in England. The Scandinavian colonies, which existed in Greenland for five hundred years, left practically no traces of their language behind them; and Arabic in Sicily, and Visigothic in Spain, have been totally extirpated.

"The Melanesians and Papuans belong to different races, and yet speak the same languages; and the same may be the case with the Lapps and Finns.

"According to Humboldt and Bonpland, 'a million of the aborigines of America have exchanged their native for an European language.' The inhabitants of San Salvador, Nicaragua, Costa Rica, etc., have exchanged their own tongues for Spanish; the inhabitants of Rio Janeiro for Portuguese. The negroes of Hayti have adopted French.

"The ancient agglutinative Accadian of Chaldea, in which a large and influential literature was written, and the first elements of Asiatic civilisation were comprised, was so completely rooted out by the conquering Semites, that the very existence of the language was unknown until the last few years."

These facts are more than sufficient to show that language is a test of social contact, and not of race. Where there are traces of two or more languages in one and the same spoken tongue, or where two distinct races have the same tongue, we can infer with absolute certainty that there has been social contact; but where such traces are not to be found, we are not justified in inferring that there has been no social contact.

Doubtless, also, identity of social relations in different communities *may* imply, and often does imply, racial affinity; but to learn this we must go elsewhere than to language. We must combine and compare the evidence derived from *all* available sources—Physiology, Philology, Anthropology, Archæology, History, Mythology, etc.—if we are to advance our knowledge of the truth.

In conclusion, I feel bound to say that there is no justification whatever in the ascertained FACTS of science for the rejection of the Biblical account of the peopling of the whole world from a single centre; nor is there any proof that we are racially Japhetic or Hamitic rather than Shemitic.

Finally, there is abundant evidence in these days, plain to all who do not wilfully refuse to see it, that one language alone (which is most certainly not Volapük), is destined to have a world-wide sway; and, further, that in the not far distant future the people, whose language is advancing in every part of the globe, will be in a position to control the destinies of the world. How true the words of Taliesin, the old bard of Kymric race, who, thirteen centuries ago, said, "Tra mor, tra Brython,"—"Wide as the sea the British name extends."

Cassava, the Food of the Caribs.

By WILLIAM DUNCAN, L.R.C.P.

(*Abstract.*)

THE Indians of Guiana are entirely occupied in procuring food—the men in hunting and fishing for animal food, the women in cultivating and preparing the Cassava (*Manihot utilissima*), which is their chief vegetable product.

The "cassava sticks," or cuttings, are planted at the beginning of the wet season, in a part of the forest which has been cleared and the undergrowth burnt down. There is no preparation of the soil, but the sticks are thrust into the ground, and in a short time have taken root. They require no attention farther than keeping down the weeds; and from the time they are planted, until nine or ten months afterwards, when they are fit for pulling up, various other plants are grown between the rows of cassava, such as pine-apple, pumpkins, yams, tobacco, etc., etc.

When the seeds appear, they show that the roots are ripe, and they are dug up as required, and two or three of the sticks are put in the ground to form the succeeding crop.

In the making of cassava bread the roots are carefully peeled and washed by one woman, and thrown on a heap. Another woman takes them from the heap, and with both hands rubs them on a rough grater which stands on a trough without ends. The grater is made by sinking pieces of stone into a block of wood, one end of which rests on the trough, and the other on the woman's knees, and as she rubs the tubers the juice runs from the trough into a pot on the floor.

The pulp is then collected and put into a matapie, or squeezer, which is a long tube of closely woven strips of bark, open at the top and closed at the bottom, and from five to six feet in length, and five or six inches in diameter. It acts on the principle of the well-known toy called the Siamese link. As it is stretched, the diameter is lessened, and the pulp is squeezed, the juice running through the meshes into a pot underneath. It is hung on one of the beams of the house and a pole inserted through a loop at the lower end, on which a woman sits, and by jumping up and down alternately lengthens and shortens the tube, thus separating the juice. The pulp now dried, is carefully sifted, and either stored in plantain leaves, or immediately made into cakes on an English griddle; or, if that is not available, on a large flat stone placed over the fire. The grains of meal soon adhere, and are then thrown on the roof of the hut to dry in the sun.

Some of the cassava is baked in thicker cakes, and kept on the griddle until quite black, to make the intoxicating liquor known as *Paiwārie.* It is then broken up and mixed with water in a jar, and the larger fragments are chewed by the women as they move about their work, while every few minutes they return to the pot and deposit in it the masticated portion and again refill their mouths, and the process thus goes on until the whole potful is well mixed with saliva. It is then boiled, and emptied into a paiwārie trough, where it remains until well fermented, when some sugar or cane juice is added to sweeten it.

The juice of the cassava which is squeezed from the matapie is boiled until all the prussic acid is driven off, and it becomes a thick, syrupy fluid known as *Casareep.* It is usually stored in bottles, but much of it is used immediately to make the staple dish of the Caribs, called Pepperpot. All kinds of animal food, mammals, fishes, and birds, if not smoked for preservation, are boiled in casareep with a large quantity of pepper, and are thus preserved in a thoroughly fresh condition for any length of time. The only disadvantage—or advantage as some think—is that all the meat is reduced to one flavour, that of the casareep itself. It is much to be regretted that this fluid, which is of such value as a flavouring and preservative agent, is not more readily procurable in this country, where it has only to be known to be thoroughly appreciated.

There are many other articles of food used by the Caribs, but they are all looked upon as luxuries. Cassava bread, pepperpot, and paiwārie, are the staple articles of diet. Curiously enough, birds' eggs are not used, although the common barn-door fowl is found at every settlement; but the eggs of turtle, iguana, and tortoise, and sometimes that of the alligator or cayman, are used abundantly. Ants, grubs, and the gru-gru worms are often used, the latter being the larva of the *Calandra palmarum.* Fruits, yams, plantains, bananas, and maize are of course plentiful, but are only used as luxuries.

Besides the paiwārie liquor, there is another drink, made from sweet potatoes and sugar-cane, called *Cassiri*, which tastes like claret; and *Gwy*, made from the sap of the Aeta palm, which tastes like Sauterne. All of them, but chiefly paiwārie, are used at the drinking feasts, which are given to all the tribes for miles around in honour of a marriage, a funeral, or the formation of a new settlement.

Reports of Meetings.

GENERAL.

IN the 29th Annual Session, which has just ended, there have been eight General Meetings of the Society, all held at University College.

On Thursday, October 2nd, 1890, Mr. Henry Charbonnier read a paper on "Bird Locomotion," copiously illustrated by specimens of the wings and feet of a great variety of birds.

On November 6th, Dr. Burder gave a short report of the rainfall of the Bristol District, and Professor Leipner gave an address on "Polyzoa," exhibiting numerous specimens and diagrams of this interesting group of creatures.

At the meeting held on December 4th, Mr. Percy Leonard read a paper entitled "Some Observations on British Mice;" stuffed and living specimens were handed round for inspection. The paper will be found printed in the Proceedings.

The meeting held on January 8th, 1891, was devoted to exhibitions and discussions. Mr. G. C. Griffiths exhibited 120 species of the genus Papilio (swallow-tailed butterflies), and remarked upon some of the most interesting; he also showed specimens of the several butterflies and moths selected by the Society for phenological observation. Mrs. Falloon exhibited a number of shells collected at Ashton. Miss P. A. Fry showed some curiosities from Madagascar, and gave some particulars about them. Mr. Henry Charbonnier exhibited and offered remarks on "Some of our Winter Visitants of the Feathered Tribe."

At the meeting held on February 5th, Mr. Edward Wethered, F.G.S., F.C.S., read a paper entitled "Evidence of the Process of the Formation of the Oolitic Rocks, as deduced from Microscopic Examination." A number of interesting photographs, and especially micro-photographs, were thrown on the screen in illustration of the lecturer's remarks.

On March 5th the Hon. Sec. (in the absence of the author, Dr. Alfred C. Fryer) read a paper on "Some Ancient Mortars," with chemical analyses of mortars found in old Roman buildings. Mr. Wm. Duncan read a paper on "Cassava, the Food of the Caribs," illustrated by models and specimens. An abstract will be found in the Proceedings.

On April 2nd, Dr. A. B. Prowse read a paper on "Language and Race," which will be found in the Proceedings.

The 29th Annual Meeting was held on May 7th, and after the Report of the Council, the Balance Sheet, and the Financial Report had been read and adopted, and the officers for the ensuing year appointed Prof. C. Lloyd Morgan delivered a Presidential Address on "The Nature and Origin of Variations." This address will be found printed in the Proceedings.

H. PERCY LEONARD,
Hon. Reporting Sec.

FINAL REPORT OF THE BOTANICAL SECTION.

AFTER an existence of nearly thirty years, the Botanical Section, as a segregate, now disappears; its members being merged in a division that will be known in future as the Biological Section. Enlarged and strengthened by the adhesion of those occupied with kindred branches of science, a useful and prosperous career may, we doubt not, be anticipated for the new organization.

Country excursions, as of old, are continued on summer Saturdays; and it is intended to hold evening meetings during the winter months, when matters of general biological interest can be discussed.

JAS. W. WHITE, F.L.S.,
Hon. Sec.

CHEMICAL AND PHYSICAL SECTION.

DURING the past session, four meetings have been held, at which the following papers were read :—

Nov. 18th. On "A New Method for Determining the Specific Volumes of Liquids and Saturated Vapours," by Prof. S. Young; and on "A Method for Determining the Acceleration of Falling Bodies," by Mr. F. Barrell.

Jan. 22nd. On "Some Properties of the Silver Chloride," by the Secretary.

Feb. 23rd. On "The Preparation of Acetal," and on "The Condensation of Camphor and Ethyl Oxalate," by Dr. Bishop Tingle.

Mar. 23rd. "Some Experiments on the Mercuro-aluminium Couple in the Estimation of Nitrates in Well Water," by the President; and on "Molecular Change in Relation to Point Discharge," by Mr. A. P. Chattock.

ARTHUR RICHARDSON,
Hon. Sec.

ENGINEERING SECTION.

AT the commencement of the session 1890–1, Mr. Francis Fox, M.I.C.E., was chosen President in place of Mr. Charles Richardson, M.I.C.E., who retired from the office in consequence of increasing deafness.

Six meetings were held. The following papers were read: "Notes on Patent Fuel and its Manufacture," Mr. Thomas Morgans; "Meters for the Measurement of Electricity supplied from a Central Source for Purposes of Light and Power," Mr. W. P. Mendham; "Some of the Water-bearing Strata, and Wells sunk in the same, with special reference to Wells in the New Red Sandstone Formation," Mr. H. W. Pearson; "Sewage Disposal," Mr. A. P. I. Cotterell; "Sewage Disposal," part 2 ("Chemical and Electrical Process of Disposal"), Mr. A. P. I. Cotterell; "Landslips," Mr. Charles Richardson.

An excursion to Swindon took place in the afternoon of Friday, June 20th, 1890. Twenty-one members and friends attended. On arrival at the Great Western Railway Company's Locomotive and Carriage Works, the party was divided into sections, separately conducted by guides provided by Mr. Dean, with whom Mr. Richardson had kindly made arrangements. A most instructive afternoon was spent. After dining at the Great Western Hotel, the party returned, reaching Bristol at 9.15 p.m.

NICHOLAS WATTS,
Hon. Sec.

INDEX

TO

PARTS I.—XIII.

OF

"The Fungi of the Bristol District."

BRISTOL NATURALISTS' SOCIETY'S PROCEEDINGS,

NEW SERIES, VOLS. II.—VI.

	NO.	VOL.	PAGE
Acrospermum			
compressum, *Tode*.	816	III.	138
Acrostalagmus			
cinnabarinus, *Corda*	785	III.	136
Actidium			
hysterioides, *Fr.*	1291	V.	131
Actinothyrium			
graminum, *Kütz.*	1104	IV.	200
Æcidium			
ari, *Berk.*	426	II.	347
compositarum, *var.* tussilaginis, *Pers.*	196	II.	215
„ *var.* bellidis, *D.C.*	423*	II.	347
crassum, *Pers.*	1423	VI.	277
epilobii, *D.C.*	421	II.	347
euphorbiæ, *Pers.*	422	II.	347
menthæ, *D.C.*	425	II.	347
primulæ, *D.C.*	778	III.	136
punctatum, *Pers.*	1425	VI.	277
quadrifidum, *D.C.*	1425	VI.	277
ranunculacearum, *D.C.*	194	II.	215
rubellum, *Pers.*	588	III.	65
thalictri, *Grev.*	423	II.	347

Æcidium—*continued.*	NO.	VOL.	PAGE
tragopogonis, *Pers.*	888	III.	266
urticæ, *D.C.*	195	II.	215
valerianacearum, *Duby.*	777	III.	136
violæ, *Schum.*	424	II.	347
Agaricus			
abhorrens, *B. & Br.*	940	IV.	55
acervatus, *Fr.*	1031	IV.	145
acicula, *Schaeff.*	289	II.	342
acutesquamosus, *Weinm.*	838	III.	262
adiposus, *Fr.*	1327	VI.	29
æruginosus, *Curt.*	61	II.	211
ætites, *Fr.*	938	IV.	55
albobrunneus, *Pers.*	1026	IV.	145
albus, *Fr.*	14	II.	208
alcalinus, *Fr.*	35	II.	209
alnicola, *Fr.*	307	II.	343
amianthinus, *Scop.*	935*	IV.	54
ammoniacus, *Fr.*	1248	V.	128
amplus, *Pers.*	1245	V.	128
antipus, *Lasch.*	312	II.	343
appendiculatus, *Bull.*	65	II.	211
applicatus, *Batsch.*	283	II.	342
aratus, *Berk.*	1256	V.	129
argyraceus, *var.* virescens, *Cooke*	1145*	V.	48
asper, *Fr.*	692	III.	131
asprellus, *Fr.*	1252	V.	129
asprellus, Fr.[1]	710	III.	133
asterospora, *Quel.*	1402*	VI.	275
atratus, *Fr.*	702	III.	132
atropunctus, *Pers.*	514	III.	61
autochthonus, *B. & Br.*	855	III.	263
bifrons, *Berk.*	1255	V.	129
Bloxami, *B. & Br.*	707	III.	133
brevipes, *Bull.*	844	III.	262
brumalis, *Fr.*	1029	IV.	145
Bucknalli, *B. & Br.*	696	III.	131
butyraceus, *Bull.*	700	III.	132
caliginosus, *Jungh.*	1368	VI.	190
campanulatus, *Linn.*	320	II.	344
campestris, *Linn.*	60	II.	211

[1] =*A. vilis, Fr.*

Agaricus—*continued.*	NO.	VOL.	PAGE
cancrinus, *Fr.*	708	III.	133
candicans, *Fr.*	697	III.	132
capillaris, *Schum.*	291	II.	342
capnoides, *Fr.*	527	III.	61
capniocephalus, *Bull.*	1088	IV.	198
carbonarius, *Fr.*	715	III.	133
carneus, *Bull.*	842	III.	262
carcharias, *Pers.*	1024	IV.	145
cepæstipes, *Sow.*	1243	V.	128
cernuus, *Müll.*	528	III.	61
cerussatus, *Fr.*	505	III.	60
cervinus, *Schaeff.*	292	II.	342
chalybæus, *Pers.*	50	II.	210
chrysophæus, *Schaeff.*	293	II.	342
cirrhatus, *Schum.*	509	III.	60
citrophyllus, *B. & Br.*	935A	IV.	54
clavipes, *Pers.*	15	II.	209
clypeatus, *Linn.*	46	II.	210
clypeolarius, *Fr.*	1242	V.	128
comptulus, *Fr.*	316	II.	344
comtulus, *Fr.* (?)	1037	IV.	146
confluens, *Pers.*	508	III.	60
conigenus, *Pers.*	1246	V.	128
conopileus, *Fr.*	318	II.	344
corrugis, *Pers.*	67	II.	211
corticola, *Schum.*	42	II.	210
cristatus, *Fr.*	7	II.	208
crustuliniformis, *Bull.*	54	II.	210
cucumis, *Pers.*	308	II.	343
cuneifolius, *Fr.*	275	II.	342
cyathiformis, *Fr.*	19	II.	209
cyphellæformis, *Berk.*	1030	IV.	145
dealbatus, *Sow.*	846	III.	262
descissus, *Fr.* (?)	950	IV.	55
disseminatus, *Fr.*	69	II.	211
dryophilus, *Bull.*	28	II.	209
durus, *Bolt.*	1367	VI.	190
echinatus, *Roth.*	718	III.	134
egenulus, *B. & Br.*	1152	V.	49
electicus, *Bucknall*	704*	III.	132
elegans, *Pers.*	29	II.	209

Agaricus—*continued.*	NO.	VOL.	PAGE
ephebius, *Fr.*	1402	VI.	275
epipterygius, *Scop.*	40	II.	209
epixanthus, *Fr.*	527*	III.	61
ermineus, *Fr.*	839	III.	262
euchrous, *Pers.*	518	III.	61
euosmus, *Berk.*	517	III.	61
eustygius, *Cooke*	1401	VI.	274
,, *Cooke*	1401	VI.	274
eutheles, *B. & Br.*	306	II.	343
excoriatus, *Schaeff.*	1145	V.	48
fagetorum, *Fr.*	937	IV.	55
fascicularis, *Hud.*	63	II.	211
fastigiatus, *Schaeff.*	520	III.	61
fibrosus, *Sow.*	55	II.	210
fibula, *Bull.*	43	II.	210
fibula, *var.* Swartzii, *Fr.*	514*	III.	61
filopes, *Bull.*	848	III.	262
fimiputris, *Bull.*	858	III.	264
flaccidus, *Sow.*	1028	IV.	145
flammans, Fr.[1]	300	II.	343
flavo-albus, *Fr.*	32	II.	209
flavo-brunneus, *Fr.*	274	II.	342
floccipes, *Fr.*	1363	VI.	189
,, *Fr.*	1363	VI.	190
flocculosus, *Berk.*	305	II.	343
fœnisecii, *Pers.*	66	II.	211
formosus, *Fr.*	852	III.	263
fragrans, *Sow.*	20	II.	209
fumosus, *Pers.*	278	II.	342
furfuraceus, *Pers.*	59	II.	211
fusipes, *Bull.*	25	II.	209
galericulatus, *Scop.*	34	II.	209
galopus, *Schrad.*	39	II.	209
gambosus, *Fr.*	13	II.	208
geophyllus, *Sow.*	57	II.	210
,, *var.* lateritius.	521	III.	61
geotrupus, Bull.[2]	280	II.	342
geotrupus, *Bull.*	1148*	V.	49
glutinosus, *Lind.*	1328	VI.	29
gracilentus, *Krombh.*	6	II.	208

---

[1] =*A. adiposus, Fr.*

[2] =*Paxillus lepista, Fr.*

Agaricus—*continued.*

	NO.	VOL.	PAGE
gracillimus, *Weinm.*	1034	IV.	146
grammopodius, *Bull.*	276	II.	342
granulosus, *Batsch.*	935	IV.	54
„ *var.* rufescens, *B. & Br.*	694	III.	131
granulosus, Batsch.[1]	8	II.	208
griseo-cyaneus, *Fr.*	947	IV.	55
griseo-pallidus, *Fr.*	1033	IV.	145
griseus, *Fr.*	944	IV.	55
hæmatopus, *Pers.*	37	II.	209
hepaticus, *Batsch.*	1365	VI.	190
hiemalis, *Osbeck.*	849	III.	262
hispidulus, *Fr.*	851	III.	263
humilis, *Fr.*	277	II.	342
hydrogrammus, *Fr.*	1251	V.	129
hydrophilus, *Bull.*	952	IV.	56
hydrophorus, *Bull.*	1257	V.	129
hypnorum, *Batsch.*	313	II.	343
imbricatus, *Fr.*	1400	VI.	274
incanus, *Fr.*	295	II.	342
incilis, *Fr.*	1148	V.	48
infundibuliformis, *Schaeff.*	18	II.	209
inunctus, *Fr.*	719	III.	134
inversus, *Scop.*	1027	IV.	145
iris, *Berk*	31	II.	209
jubatus, *Fr.*	946	IV.	55
laccatus, *Scop.*	21	II.	209
lacerus, Fr.[2]	304	II.	343
lacrymabundus, *Fr.*	1330	VI.	29
lachrymabundus, Fr.[3]	64	II.	211
lacteus, *Pers.*	33	II.	209
lampropus, *Fr.*	49	II.	210
lanuginosus, *Bull.*	1329	VI.	29
lascivus, *var.* robustus, *Fr.*	1085	IV.	198
lateritius, *Fr.*	311	II.	343
Leightoni, *Berk.*	1325	VI.	29
lentus, *Pers.*	1253	V.	129
leptocephalus, *Pers.*	287	II.	342
leucotephrus, *B. & Br.*	1090	IV.	199
lignatilis, *Pers.*	281	II.	342
lineatus, *Bull.*	847	III.	262

[1] =*A. amianthinus, Scop.* [2] =*A. asterospora, Quel.* [3] =*A. velutinus, Pers.*

Agaricus—*continued.*	NO.	VOL.	PAGE
longicaudus, *Pers.*	523	III.	61
longipes, *Bull.*	284	II.	342
lubricus, *Fr.*	1254	V.	129
maculatus, *A. & S.*	1323	VI.	29
mammosus, *Fr.*	51	II.	210
mappa, *Fr.*	272	II.	341
marginatus, *Batsch.*	713	III.	133
maurus, *Fr.*	1364	VI.	190
maximus, *Fr.*	1322	VI.	29
maximus, *Fr.*[1]	17	II.	209
melinoides, *Fr.*	716	III.	133
melleus, *Vahl.*	9	II.	208
merdarius, *Fr.*	1403	VI.	275
mesophæus, *Pers.*	714	III.	133
metachrous, *Fr.*	506	III.	60
mollis, *Schaeff.*	524	III.	61
mucidus, *Schrad.*	273	II.	341
muralis, *Sow.*	1086	IV.	198
muricatus, *var.* gracilis, *Quel.*	712	III.	133
murinaceus, *Bull.*	503	III.	60
muscarius, *Linn.*	3	II.	208
mutabilis, *Schaeff.*	301	II.	343
mutilus, *Fr.*[2]	22	II.	209
nanus, *Pers.*	515	III.	61
nanus, *var.* lutescens, *Pers.*	515*	III.	61
nebularis, *Fr.*	1146	V.	48
nidorosus, *Fr.*	294	II.	342
nudus, *Bull.*	842*	III.	262
nudus, *Bull.*[3]	76	II.	211
odorus, *Bull.*	16	II.	209
ombrophilus, *Fr.*	949	IV.	55
opacus, *With.*	1147	V.	48
ostreatus, *Jacq.*	23	II.	209
ovoideus, *Bull.*	690	III.	131
panæolus, *Fr.*	843	III.	262
pantherinus, *Fr.*	691	III.	131
pantoleucus, *Fr.*	850	III.	263
papilionaceus, *Fr.*	321	II.	344

---

[1] =*A. nebularis, Fr.*

[2] Probably a lateral-stemmed form of *A. subpulverulentus, Pers.*

[3] =*A. sordidus, Fr.*

Agaricus—*continued.*

	NO.	VOL.	PAGE
Parkensis, *Fr.*	948	IV.	55
parvulus, *Weinm.*	44	II.	210
pascuus, *Pers.*	519	III.	61
pelianthinus, *Fr.*	1247	V.	128
pelliculosus, *Fr.*	1031*	IV.	145
pennatus, *Fr.*	857	III.	263
personatus, *Fr.*	77	II.	211
petiginosus, *Fr.*	853	III.	263
phalloides, *Fr.*	2	II.	208
Phillipsii, *B. & Br.*	856	III.	263
pisciodorus, *Ces.*	1149	V.	49
platyphyllus, *Fr.*	699	III.	132
polygrammus, *Bull.*	286	II.	342
polystictus, *Berk.*	1025	IV.	145
præcox, *Pers.*	297	II.	343
procerus, *Scop.*	693	III.	131
pronus, *Fr.*	322	II.	344
prunuloides, *Fr.*	706	III.	133
prunulus, *Scop.*	47	II.	210
pseudoandrosaceus, *Bull.*	942	IV.	55
pterigenus, *Fr.*	1032	IV.	145
pudicus, *Bull.*	711	III.	133
purus, *Pers.*	30	II.	209
pyriodorus, *Pers.*	303	II.	343
rachodes, *Vitt.*	5	II.	208
radicatus, *Relh.*	24	II.	209
radicosus, *Bull.*	298	II.	343
rancidus, *Fr.*	701	III.	132
repandus, *Bull.*	1087	IV.	198
reticulatus, *Pers.*	310	II.	343
retirugis, *Fr.*	319	II.	344
rimosus, *Bull.*	56	II.	210
roridus, *Fr.*	512	III.	60
rubescens, *Pers.*	4	II.	208
rubi, *Berk.*	525	III.	61
rufo-carneus, *Berk.*	52	II.	210
rugosus, *Fr.*	703	III.	132
rutilans, *Schaeff.*	10	II.	208
sacchariferus, B. & Br.[1]	513	III.	60
" *B. & Br.*		III.	133

[1] = *A. electicus, Bucknall.*

Agaricus—*continued.*	NO.	VOL.	PAGE
salicinus, *Pers.*	1326	VI.	29
sanguinolentus, *A. & S.*	38	II.	209
saponaceus, *Fr.*	504	III.	60
sarcocephalus, *Fr.*	720	III.	134
scabellus, *Fr.*	522	III.	61
scalpturatus, *Fr.*[1]	11	II.	208
sejunctus, *Fr.*	936	IV.	54
semiglobatus, *Batsch.*	315	II.	343
semilanceatus, *Fr.*	953	IV.	56
seminudus, *Lasch.*	695	III.	131
„ *var. lilacinus, Quel.*		III.	132
semiorbicularis, *Bull.*	309	II.	343
semivestitus, *B. & Br.*	1154	V.	49
separatus, *Linn.*	68	II.	211
septicus, *Fr.*	282	II.	342
sericellus, *Fr.*	516	III.	61
sericeus, *Bull.*	1366	VI.	190
serrulatus, *Pers.*	1036	IV.	146
setosus, *Sow.*	939	IV.	55
sinapizans, *Fr.*	302	II.	343
sinuatus, *Fr.*	1035	IV.	146
solitarius, *Bull.*	1241	V.	126
„ *Bull.*	1241	V.	128
solstitialis, *Fr.*	709	III.	133
sordidus, *Fr.*	845	III.	262
spadiceo-griseus, *Schaeff.*	1153	V.	49
spadiceus, *Schaeff.*	317	II.	344
sparteus, *Fr.*	1150	V.	49
spectabilis, *Fr.*	299	II.	343
speireus, *Fr.*	288	II.	342
squamosus, *Fr.*	314	II.	343
squarrosus, *Müll.*	53	II.	210
stanneus, *Fr.*	1249	V.	128
stercorarius, *Fr.*	951	IV.	56
stellatus, *Fr.*	943	IV.	55
strangulatus, *Fr.*	502	III.	60
striæpes, *Cooke*	1089	IV.	198
strobiliformis, *Fr.*	837	III.	262
stylobates, *Pers.*	41	II.	210
sublateritius, *Fr.*[2]	62	II.	211

[1] =*A. argyraceus*, var. *virescens*, *Cooke*.

[2] =*A. epixanthus*, *Fr.*

Agaricus—*continued.*	NO.	VOL.	PAGE
sublateritius, *Schaeff.*	526	III.	61
subpalmatus, *Fr.*	698	III.	132
sudorus, *Fr.*	704	III.	132
sulphureus, *Bull.*	841	III.	262
sylvaticus, *Schaeff.*	1151	V.	49
Taylori, *Berk.*	705	III.	133
tenacellus, *Pers.*	1324	VI.	29
tener, *Schaeff.*	58	II.	210
tenerrimus, *Berk.*	290	II.	342
terreus, *Schaeff.*	12	II.	208
„ *var.* argyraceus, *Bull.*	696*	III.	132
testaceus, *Batsch.*	854	III.	263
togularis, *Bull.*	296	II.	343
tremulus, *Schaeff.*	507	III.	60
tuberosus, *Bull.*	27	II.	209
tumulosus, *Kalch.*	279	II.	342
„ *Kalch.*		II.	350
ulmarius, *Bull.*	945	IV.	55
umbelliferus, *Linn.*	941	IV.	55
umbrosus, Pers.[1]	45	II.	210
ustalis, *Fr.*	840	III.	262
vaccinus, *Pers.*	1244	V.	128
vaginatus, *Bull.*	1	II.	208
variabilis, *Pers.*	48	II.	210
velutinus, *Pers.*	315*	II.	343
velutipes, *Curt.*	26	II.	209
vertirugis, *Cooke*	285	II.	342
vestitus, *Fr.*	717	III.	133
vilis, *Fr.*	1087*	IV.	198
vitilis, *Fr.*	36	II.	209
vulgaris, *Pers.*	1250	V.	129
vulgaris, Pers.[2]	511	III.	60
xanthopus, *Fr.*	510	III.	60
Anixia			
perichænoides, *Cooke*	1240	V.	54
Anthostoma			
italicum, *Sacc.*	1219*	V.	52
Arcyria			
cinerea, *Bull.*	570	III.	64
incarnata, *Pers.*	571	III.	64

---

[1] =*A. cervinus, Schaeff.*

[2] =*A. pelliculosus, Fr.*

Arcyria—*continued.*	NO.	VOL.	PAGE
nutans, *Fr.*	386	II.	346
„ *Bull.*	571*	III.	64
pomiformis, *Roth.*	569	III.	64
punicea, *Pers.*	161	II.	214
„ *Pers.*	568*	III.	64
Arthrinium			
sporophlœum, *Kütz.*	896	III.	266
Arthrobotryum			
atrum, *B. & Br.*	986	IV.	58
Ascobolus			
argenteus (Ascophanus) *Curr.*	810	III.	138
argenteus (Ryparobius) *B. & Br.*	812	III.	138
carneus, *Pers.*	909	III.	267
ciliatus, *Schum.*	464	II.	349
denudatus, *Fr.*	1001	IV.	58
furfuraceus, *Pers.*	639	III.	68
glaber, *Pers.*	807	III.	137
granuliformis, *Crouan*	640	III.	68
immersus, *Pers.*	808	III.	137
lacteus, *C. & Ph.*	642	III.	68
neglectus, *Boud.*	809	III.	138
Pelletièri, *Crouan*	641	III.	68
sexdecemsporus, *Crouan*	811	III.	138
vinosus, *Berk.*	806	III.	137
Ascophora			
mucedo, *Tode*	1287	V.	130
Aspergillus			
virens, *Link.*	595	III.	65
Asterosporium			
Hoffmannii, *M. & N.*	171	II.	214
Auricularia			
mesenterica, *Bull.*	132	II.	213
Bactridium			
flavum, *Kütz.*	175	II.	214
Badhamia			
hyalina, *Berk.*	381*	II.	346
„ *Pers.*	562*	III.	63
utricularis, *Berk.*	382	II.	346
„ *Bull.*	562*	III.	63
utricularis, Berk.[1]	158	II.	214

---

[1] =*B. hyalina, Berk.*

	NO.	VOL.	PAGE
Belonidium			
pullum, Ph. & K.	628	III.	68
Bispora			
monilioides, *Corda*	396	II.	346
Bolbitius			
Boltoni, *Fr.*	1370	VI.	190
titubans, *Fr.*	325	II.	344
Boletus			
badius, *Fr.*	870	III.	264
candicans, *Fr.*	747	III.	135
castaneus, *Bull.*	1340	VI.	31
chrysenteron, *Fr.*	107	II.	212
edulis, *Bull.*	748	III.	135
,, *Bull.*	871	III.	264
elegans, *Schum.*	542	III.	62
flavus, *With.*	1339	VI.	31
granulatus, *Linn.*	106	II.	212
laricinus, *Berk.*	105	II.	212
luridus, *Fr.*	108	II.	212
piperatus, *Bull.*	744	III.	135
scaber, *Fr.*	109	II.	212
subtomentosus, *Linn.*	745	III.	135
tenuipes, *Cooke*	1414	VI.	276
variecolor, *B. & Br.*	746	III.	135
Botryosporium			
pulchrum, *Corda*	784	III.	136
Bovista			
plumbea, *Pers.*	762	III.	135
Brefeldia			
maxima, *Fr.*	567*	III.	64
Bulgaria			
inquinans, *Fr.*	225	II.	216
pulla, *Fr.*	1075	IV.	149
sarcoides, *Fr.*	226	II.	216
Byssosphæria			
aquila, *Fr.*	666	III.	69
Calocera			
cornea, *Fr.*	142	II.	213
glossoides, *Fr.*	371	II.	346
viscosa, *Fr.*	1066	IV.	148

	NO.	VOL.	PAGE
Cantharellus			
aurantiacus, *Fr.*	1159	V.	49
carbonarius, *A. & S.*	1372	VI.	191
cibarius, *Fr.*	99	II.	212
cupulatus, *Pers.*	539	III.	62
infundibuliformis, *Fr.*	740	III.	135
Capnodium			
sphæricum, *Cooke*	271	II.	218
Cephalotheca			
sulphurea, *Fckl.*	600	III.	66
Ceratium			
hydnoides, *A. & S.*	427	II.	347
Ceratostoma			
ampullasca, *Cooke*	665	III.	69
caprinum, *Fr.*	269	II.	218
Ceriospora			
xantha, *Sacc.*	1227	V.	48
„ *Sacc.*	1227	V.	53
Ceuthospora			
lauri, *Grev.*	169	II.	214
phacidioides, *Grev.*	1173	V.	50
Chætodiplodia			
caulina, *Karst.*	1164	V.	47
„ *Karst.*	1164	V.	49
Chætomium			
elatum, *Kütz.*	789	III.	136
Chondrioderma			
difforme, *Pers.*	883	III.	266
radiatum, *Linn.*	1069	IV.	148
Cladosporium			
herbarum, *Link.*	780	III.	136
Clathroptychium			
rugulosum, *Wallr.*	567*	III.	64
Clavaria			
abietina, *Pers.*	556	III.	63
aculina, *Quel.*	968	IV.	56
acuta, *Sow.*	370	II.	345
Ardenia, *Sow.*	1065	IV.	148
aurea, *Schaeff.*	757	III.	135
cinerea, *Bull.*	138	II.	213
coralloides, *Linn.*	966	IV.	56
cristata, *Holmsk.*	139	II.	213

	NO.	VOL.	PAGE
Clavaria—*continued.*			
cristata, *Pers.*	1064	IV.	148
fastigiata, *D.C.*	136	II.	213
formosa, *Pers.*	967	IV.	56
fragilis, *Holmsk.*	141	II.	213
fusiformis, *Sow.*	880	III.	265
inæqualis, *Mull.*	369	II.	345
juncea, *Fr.*	557	III.	63
lilacina, *Fr.*	1345	VI.	32
muscoides, *Linn.*	137	II.	213
pistillaris, *Linn.*	759	III.	135
purpurea, *Schaeff.*		VI.	32
rugosa, *Bull.*	140	II.	213
stricta, *Pers.*	1346	VI.	32
umbrina, *Berk.*	1063	IV.	148
uncialis, *Grev.*	760	III.	135
vermiculata, *Scop.*	758	III.	135
Claviceps			
microcephala, *Tul.*	469	II.	349
Coccotrichum			
brevius, *B. & Br.*	781	III.	136
Coleosporium			
rhinanthacearum, *Lev.*	586	III.	65
senecionis, *Pers.*		VI.	
sonchi-arvensis, *Lev.*	412	II.	347
tussilaginis, *Lev.*	188	II.	215
Colpoma			
quercinum, *Wallr.*	1116	IV.	201
Comatricha			
Friesiana, *D. By.*	567*	III.	64
" *var. A.* obovata	567*	III.	64
" *var. B.* oblonga	567*	III.	64
Conisphæria			
pæcilostoma, *B. & Br.*	1314	V.	132
pertusa, *Pers.*	672	III.	69
Coprinus			
atramentarius, *Fr.*	71	II.	211
cinereus, *Schaeff.*	1091	IV.	199
comatus, *Fr.*	70	II.	211
domesticus, *Fr.*	1369	VI.	190
ephemerus, *Fr.*	722	III.	134
fimetarius, *var.* pullatus, *Bolt.*	1258	V.	129

	NO.	VOL.	PAGE
Coprinus—*continued.*			
lagopus, *Fr.*	73	II.	211
micaceus, *Fr.*	72	II.	211
niveus, *Fr.*	324	II.	344
nycthemerus, *Fr.*	859	III.	264
plicatilis, *Fr.*	74	II.	211
radiatus, *Fr.*	721	III.	134
tomentosus, *Fr.*	323	II.	344
Cornuvia			
metallica, *B. & Br.*	568*	III.	64
Corticium			
arachnoideum, *Berk.*	361	II.	345
cæruleum, *Fr.*	133	II.	213
cinereum, *Fr.*	135	II.	213
comedens, *Fr.*	365	II.	345
incarnatum, *Fr.*	555	III.	63
lactescens, *Berk.*	363	II.	345
læve, *Pers.*	362	II.	345
puberum, *Fr.*[1]	364	II.	345
quercinum, *Pers.*	134	II.	213
sambuci, *Fr.*	366	II.	345
sanguineum, *Fr.*	1062	IV.	148
Cortinarius			
acutus, *Fr.*	532	III.	62
anfractus, *Fr.*	1039	IV.	146
anomalus, *Fr.*	861	III.	264
Armeniacus, *Fr.*[2]	330	II.	344
arvinaceus, *Fr.*	1043	IV.	147
„ *Fr.*	1094*	IV.	199
bicolor, *Cooke*	1333*	VI.	28
„ *Cooke*	1333*	VI.	30
bivelus, *Fr.*[3]	1263	V.	129
Bulliardi, *Fr.*	727	III.	134
cærulescens, *Fr.*	725	III.	134
calochrous, *Fr.*	1040	IV.	146
camurus, *Fr.*	1262	V.	129
castaneus, *Fr.*	1050	IV.	147
cinnamomeus, *Fr.*	328	II.	344
claricolor, *Fr.*	723	III.	134
colus, *Fr.*	1051	IV.	147

---

[1] = *C. læve, Pers.*

[2] Probably *C. saturninus, Fr.*

[3] = *C. laniger, Fr.*

Cortinarius—*continued.*

	NO.	VOL.	PAGE
cotoneus, *Fr.*[1]	862	III.	264
croceo-cæruleus, *Fr.*	1094	IV.	199
cyanopus, *Fr.*	1259	V.	129
decipiens, *Fr.*	1053	IV.	147
decoloratus, *Fr.* (?)	326	II.	344
diabolicus, *Fr.*[2]	327	II.	344
dilutus, *Fr.*	1049	IV.	147
elatior, *Fr.*	726	III.	134
emollitus, *Fr.*	1261	V.	129
firmus, *Fr.*	729	III.	134
flexipes, *Fr.*	329	II.	344
,, *Fr.*		II.	350
fulgens, *Fr.*	1093	IV.	199
germanus, *Fr.*	1054	IV.	148
glaucopus, *Fr.*	1092	IV.	199
helvolus, *Fr.*	1047	IV.	147
hinnuleus, *Fr.*	1048	IV.	147
injucundus, *Weinm.*	1333	VI.	30
laniger, *Fr.*	1331*	VI.	29
largus, *Fr.*	529	III.	62
leucopus, *Fr.*	1052	IV.	147
licinipes, *Fr.*	728	III.	134
limonius, *Fr.*	1332*	VI.	30
macropus, *Fr.*	1095	IV.	199
mucifluus, *Fr.*	1044	IV.	147
multiformis, *Fr.*	724	III.	134
nitrosus, *Cooke*	1332	VI.	28
,, *Cooke*	1332	VI.	29
ochroleucus, *Fr.*	1156	V.	49
orellanus, *Fr.*	1406	VI.	275
paleaceus, *Fr.*	531*	III.	62
,, *Weinm, var.*	955*	IV.	56
papulosus, *Fr.*	1042	IV.	146
,, *Fr.*	1094*	IV.	199
penicellatus, *Fr.*	1155	V.	47
,, *Fr.*	1155	V.	49
percomis, *Fr.*[3]	1038	IV.	146
prasinus, *Fr.*	1041	IV.	146
privignus, *Fr.*	1264	V.	129
purpurascens, *Fr.*	75	II.	211

[1] Probably *C. sublanatus*, *Fr.*

[2] = *C. paleaceus*, *Fr.*

[3] = *C. limonius*, *Fr.*

Cortinarius—*continued.*	NO.	VOL.	PAGE
purpurascens, *Fr.*	1404*	VI.	275
quadricolor, Fr.[1]	1046	IV.	147
" *Fr.*	1094*	IV.	199
raphanoides, *Fr.*	863	III.	264
Riederi, *Fr.*	530	III.	62
rigens, *Fr.*	956	IV.	56
rigidus, *Scop.*	1407	VI.	275
russus, *Fr.*[2]	860	III.	264
sanguineus, *Fr.*	954	IV.	56
saturninus, *Fr.*	1157	V.	49
scandens, *Fr.*	1265	V.	129
scaurus, *Fr.*	1260	V.	129
scutulatus, *Fr.*	955	IV.	56
subferrugineus, *Fr.*	1096	IV.	199
sublanatus, *Fr.*	1045	IV.	147
testaceus, *Cooke*	1404	VI.	274
" *Cooke*	1404	VI.	275
torvus, *Fr.*	531	III.	62
triumphans, *Fr.*	1371	VI.	190
varius, *Fr.*	1331	VI.	29
violaceus, *Fr.*	1405	VI.	275
Coryneum			
microstictum, *B. & Br.*	582	III.	65
Craterellus			
cornucopioides, *Pers.*	876	III.	265
crispus, *Fr.*	1416	VI.	276
sinuosus, *Fr.*	123	II.	213
Craterium			
minutum, *Leers.*	565	III.	64
vulgare, *Ditm.*	1281	V.	130
Cribaria			
intricata, *Schrad.*	160	II.	214
" *Schrad.*	568*	III.	64
microcarpa, *Rost.*	1380	VI.	189
" *Rost.*	1380	VI.	191
Crucibulum			
vulgare, *Tul.*	574	III.	65
Cryptovalsa			
Nitschkei, *Fckl.*	1299	V.	127
" *Fckl.*	1299	V.	131

---

[1] =*C. bicolor, Cooke.*

[2] =*C. testaceus, Cooke.*

	NO.	VOL.	PAGE
Cucurbitaria			
berberidis, *Gray*	1014	IV.	59
" *Gray*	1081*	IV.	150
cupularis, *Fr.*	1204	V.	51
Cyathus			
striatus, *Hoff.*	766	III.	136
vernicosus, *D.C.*	1162	V.	49
Cynophallus			
caninus, *Fr.*	148	II.	214
Cyphella			
capula, *Fr.*	368	II.	345
Curreyi, *B. & Br.*	878	III.	265
faginea, *Lib.*	879	III.	265
griseo-pallida, *Weinm.*	1377	VI.	191
pallida, *B. & Br.*	756	III.	135
punctiformis, Karst.		III.	265
rubi, *Fckl.*	1418	VI.	276
villosa, *Pers.*		III.	265
Cystopus			
candidus, *Lev.*	190	II.	215
cubicus, *Str.*	189	II.	215
lepigoni, *D. By.*	191	II.	215
Cytospora			
pinastri, *Fr.*	1109	IV.	200
Dacrymyces			
cæsius, *Fr.*	1347	VI.	28
" *Fr.*	1347	VI.	32
chrysocomus, *Tul.*	971	IV.	57
stillatus, *Nees.*	1103	IV.	200
Dactylium			
roseum, *Berk.*	782	III.	133
Dædalea			
confragosa, *Pers.*	1273	V.	130
quercina, *Pers.*	118	II.	213
unicolor, *Fr.*	549	III.	63
Darluca			
filum, *Cast.*	1174	V.	50
macropus, *B. & Br.*	167	II.	214
Dendryphium			
curtum, *B. & Br.*	199	II.	215
Dermatea			
dryina, *Cooke*	638	III.	68

	NO.	VOL.	PAGE
Diachæa			
leucopoda, *Bull.*	975	IV.	57
Diaporthe			
acus, *Blox.*	1121	IV.	201
arctii, *Lasch.*	1122	IV.	201
Beckhausii, *Nke.*	1202	V.	48
,, *Nke.*	1202	V.	51
blepharodes, *B. & Br.*	1125	IV.	201
circumscripta, *Otth.*	1203	V.	48
,, *Otth.*	1203	V.	51
crustosa, *Sacc. & Roum.*	1305	V.	127
,, *Sacc. & Roum.*	1305	V.	131
discors, *Sacc.*	1123	IV.	201
discrepans, *Sacc.*	1301	V.	127
,, *Sacc.*	1301	V.	131
discutiens, *Berk.*	1304	V.	131
epilobii, *Cooke*	1306	V.	132
euphorbiæ, *Cooke*	1011	IV.	59
ilicina, *Cooke*	819	III.	138
inæqualis, *Curr.*	1200	V.	51
incarcerata, *B. & Br.*	1124	IV.	201
Laschii, *Nke.*	1010	IV.	59
lyrella, *M. & N.*	918	III.	268
pantherina, *Berk.*	652	III.	69
protracta, *Nits.*	1120	IV.	201
pulla, *Nits.*	1119	IV.	201
pustulata, *Desm.*	1013	IV.	59
quercus, *Fckl.*	1302	V.	127
,, *Fckl.*	1302	V.	131
revellens, *Nke.*	1201	V.	47
,, *Nke.*	1201	V.	51
sarothamni, *Awd.*	1303	V.	131
scobina, *Nke.*	651	III.	68
spiculosa, *Pers.*	650	III.	68
Tulasnei, *Nke.*	1300	V.	127
,, *Nke.*	1300	V.	131
velata, *Pers.*	1009	IV.	59
Diatrype			
angulata, *Fr.*	655	III.	69
aspera, *Fr.*	653	III.	69
berberidis, *Cooke*	1190	V.	51
brassicæ, *Cooke*	1189	V.	51

Diatrype—*continued.*	NO.	VOL.	PAGE
bullata, *Fr.*	1292	V.	131
disciformis, *Fr.*	1127	IV.	201
favacea, *Fr.*	250	II.	217
ferruginea, *Fr.*	656	III.	69
podoides. *Fr.*	252	II.	217
stigma, *Fr.*	251	II.	217
strumella, *Fr.*	1126	IV.	201
verruciformis, *Fr.*	654	III.	69
Dictydium			
cernuum, *Pers.*	568	III.	64
Dictyosporium			
elegans, *Corda*	583	III.	65
Didymella			
sæpincoliformis, *De Not.*	1221*	V.	53
Didymium			
cinereum, *Fr.*	381	II.	346
clavus, *A. & S.*	1350	VI.	32
farinaceum, *Fr.*	380	II.	346
hemisphæricum, *Fr.*	378	II.	346
microcarpon, *Fr.*	974	IV.	57
nigripes, *Fr.*	156	II.	214
squamulosum, *A. & G.*	379	II.	346
" *A. & G.*	567*	III.	64
Didymosphæria			
conoidea, *Niessl.*	1220	V.	53
Dinemasporium			
graminum, *Lev.*	394	II.	346
graminum, *var.* herbarum, *Cooke*	770	III.	136
Diplodia			
fibricola, *Berk.*	769	III.	136
herbarum, *Lev.*	578	III.	65
rubi, *Fr.*	1107	IV.	200
sapinea, *Fr.*	1106	IV.	200
Scheidweileri, *West.*	1163	V.	49
vulgaris, *Lev.*	577	III.	65
Discella			
microsperma, *B. & Br.*	581	III.	65
Discosea			
alnea, *Lib.*	580	III.	65
Dothidea			
caricis, *Fr.*	1008	IV.	59

Dothidea—*continued.*	NO.	VOL.	PAGE
filicina, *Fr.*	818	III.	138
graminis, *Fr.*	479	II.	349
Johnstoni, *B. & Br.*	480	II.	349
junci, *Fr.*	478	II.	349
trifolii, *Fr.*	477	II.	349
ulmi, *Fr.*	476	II.	349
Dothiora			
sphæroides, *Fr.*	576	III.	65
Elaphomyces			
granulatus, *Fr.*	1003	IV.	59
Endogone			
pisiformis, *Link.*	989	IV.	58
Enerthenema			
elegans, *Bowm.*	385	II.	346
papillata, *Pers.*	567*	III.	64
Epichloe			
typhina, *Berk.*	235	II.	217
Epicoccum			
neglectum, *Desm.*	779	III.	136
Erysiphe			
communis, *Schl.*	788	III.	136
lamprocarpa, *Lev.*	786	III.	136
Montagnei, *Lev.*	990	IV.	58
tortilis, *Link.*	787	III.	136
Eutypa			
Acharii, *Tul.*	648	III.	68
flavo-virens, *Tul.*	1117	IV.	201
lata, *Pers.*	1191	V.	51
leioplaca, *Fr.*	1192	V.	51
rhodi, *Fckl.*	1118	IV.	201
scabrosa, *Fckl.*	649	III.	68
spinosa, *Tul.*	917	III.	268
Exidia			
glandulosa, *Fr.*	146	II.	214
Fenestella			
princeps, *Tul.*	1199	V.	51
Fistulina			
hepatica, *Fr.*	120	II.	213
Fuligo			
varians, *Sommf.*	564	III.	63

Fusarium NO. VOL. PAGE
equiseti, *Desm.* . . . . . . 1182 V. 50
Fusidium
album, *Desm.* . . . . 783 III. 136
flavo-virens, *Fr.* . . . . . . 596 III. 65
Fusisporium
fœni, *B. & Br.* . . . . . . 1286 V. 130

Geaster
Bryantii, *Berk.* . . . . . . 1068 IV. 148
fimbriatus, *Fr.* . . . . . . 973 IV. 57
Genea
hispidula, *Berk.* . . . . . . 1076 IV. 150
Geoglossum
glabrum, *Pers.* . . . . . . 603 III. 66
glutinosum, *Pers.* . . . . . . 992 IV. 58
hirsutum, *Pers.* . . . . . . 604 III. 66
microsporum, *Cooke & Peck* . . . . 1072 IV. 149
viride, *Pers.* . . . . 991 IV. 58
Gibbera
Saubinetii, *Mont.* . . . . . . 481 II. 349
Gnomonia
setacea, *var.* petiolæ, *Pers.* . . . . . 689 III. 70
vulgaris, *Ces. & De Not.* . . . . . 1321 V. 132
Gomphidius
stellatus, *Strauss* . . . . . . 864 III. 264
viscidus, *Fr.* . . . . 85 II. 212
Gonatosporium
puccinioides, *Berk.* . . . . 594 III. 65
Grandinia
granulosa, *Fr.* . . . . . . 356 II. 345

Haplographium
delicatum, *B. & Br.* . . . . . 892 III. 266
Helicoryne
viridis, *Corda* . . . . 205 II. 216
Helminthosporium
apicale, *B. & Br.* . . . . . . 432 II. 347
delicatulum, *Berk.* . . . . . 592 III. 65
folliculatum, *Corda* . . . . . . 430 II. 347
" *var.* B., *Corda* . . . . . 893 III. 266
fusisporium, *Berk.* . . . . 203 II. 216

	NO.	VOL.	PAGE
Helminthosporium—*continued.*			
macrocarpum, *Grev.*	202	II.	216
oosporum, *Corda*	895	III.	266
Smithii, *B. & Br.*	429	II.	347
subulatum, *Nees.*	590	III.	65
tiliæ, *Fr.*	894	III.	266
turbinatum, *B. & Br.*	431	II.	347
velutinum, *Link.*	591	III.	65
Helotium			
æruginosum, *Fr.*	629	III.	68
albopunctum, *Desm.*	805	III.	137
citrinum, *Fr.*	630	III.	68
claroflavum, *Berk.*	462	II.	349
delicatulum, *Berk.*	592	III.	65
deparculum, *Karst*	1429	VI.	274
,, *Karst*	1429	VI.	277
epiphyllum, *Fr.*	632	III.	68
fagineum, *Fr.*	804	III.	137
flavum, *Klotsch.*	802	III.	137
fructigenum, *Bull.*			
herbarum, *Fr.*	463	II.	349
pallescens, *Fr.*	803	III.	137
pruinosum, *Jerd.*	631	III.	68
salicellum, *Fr.*	1000	IV.	58
sclerotioides, *Berk.*	461	II.	348
virgultorum, Fr.[1]	224	II.	216
Helvella			
crispa, *Fr.*	445	II.	348
crispa, Fr.[2]	213	II.	216
elastica, *Bull.*	445*	II.	348
lacunosa, *Afz.*	214	II.	216
Hemiarcyria			
Bucknalli, *Massee*	1381	VI.	189
,, *Massee*	1381	VI.	192
clavata, *Pers.*	1352	VI.	32
rubiformis, *Pers.*	573	III.	64
Hendersonia			
corni, *Fckl.*	579	III.	65
graminicola, *Lev.*	884	III.	266
hapalocystis, *Cooke*	1379	VI.	189
,, *Cooke*	1379	VI.	191

[1] =*H. fructigenum, Bull.*

[2] =*H. elastica, Bull.*

	NO.	VOL.	PAGE
Hendersonia—*continued.*			
loricata, *Sacc. & Roum.*	1108	IV.	200
phragmitis, *Desm.*	1169	V.	47
„ *Desm.*	1169	V.	50
riparia, *Sacc.*	1168	V.	47
„ *Sacc.*	1168	V.	50
rubi, *West*	1166	V.	49
salicina, *Vize*	1167	V.	50
sarmentorum, *West*	1165	V.	49
Stephensii, *B. & Br.*	980	IV.	57
Heterosphæria			
patella, *Grev.*	813	III.	138
Hirneola			
auricula-Judæ, *Berk.*	147	II.	214
Hydnangium			
carotæcolor, *Berk.*	972	IV.	57
„ *Berk.*	1066*	IV.	148
Hydnobolites			
cerebriformis, *Tul.*	644	III.	68
Hydnum			
auriscalpium, *Linn.*	122	II.	213
coralloides, *Scop.*	1376	VI.	191
farinaceum, *Pers.*	552	III.	63
ferruginosum, *Fr.*	550	III.	63
fusco-atrum, *Fr.*	1274	V.	127
„ *Fr.*	1274	V.	130
niveum, *Pers.*	553	III.	63
ochraceum, *Pers.*	353	II.	345
repandum, *Linn.*	121	II.	213
udum, *Fr.*	551	III.	63
variecolor, *Fr.*	755	III.	135
Hygrophorus			
arbustivus, *Fr.*	80	II.	211
ceraceus, *Fr.*	733	III.	134
chlorophanus, *Fr.*	1055	IV.	148
chrysodon, *Fr.*	731	III.	134
coccineus, *Fr.*	82	II.	212
conicus, *Fr.*	83	II.	212
cossus, *Fr.*	79	II.	211
eburneus, *Fr.*	533	III.	62
fornicatus, *Fr.*	958	IV.	56
Houghtoni, *B. & Br.*	960	IV.	56

	NO.	VOL.	PAGE
Hygrophorus—*continued.*			
hypothejus, *Fr.*	1266	V.	129
limacinus, *Fr.*	732	III.	134
miniatus, *Fr.*	961	IV.	56
murinaceus, *Fr.*	962	IV.	56
ovinus, *Fr.*	959	IV.	56
pratensis, *Fr.*	331	II.	344
psittacinus, *Fr.*	84	II.	212
puniceus, *Fr.*	535	III.	62
russo-coriaceus, *B. & Br.*	534	III.	62
unguinosus, *Fr.*	734	III.	134
virgineus, *Fr.*	81	II.	212
Hymenochæta			
corrugata, *Berk.*	131	II.	213
rubiginosa, *Lev.*	130	II.	213
Hymenogaster			
olivaceus, *Vitt.*	1067	IV.	148
pallidus, *B. & Br.*	373	II.	346
tener, *Berk.*	562	III.	63
vulgaris, *Tul.*	561	III.	63
Hymenoscypha			
tuberosa, *Bull.*	1388	VI.	193
Hypocrea			
rufa, *Pers.*	1396	VI.	194
Hypomyces			
asterophora, *Tul.*	914*	III.	268
aurantius, *Tul.*	237	II.	217
Broomeanus, *Tul.*	815	III.	138
Linkii, *Tul.*	1079	IV.	150
luteo-virens, *Tul.*	814	III.	138
ochraceus, *Tul.*	236	II.	217
rosellus, *Tul.*	1078	IV.	150
torminosus, *Tul.*	470	II.	349
Hypospila			
viburni, *Bucknall*	1080	IV.	150
„ *Bucknall*	1187*	V.	50
Hypoxylon			
atro-purpureum, Fr.	475	II.	349
coccineum, *Bull.*	474	II.	349
cohærens, *Fr.*	1188	V.	50
concentricum, *Grev.*	244	II.	217
fuscum, *Fr.*	246	II.	217

	NO.	VOL.	PAGE
Hypoxylon—*continued.*			
multiforme, *Fr.*	245	II.	217
rubiginosum, *Fr.*	247	II.	217
udum, *Fr.*	248	II.	217
Hysterium			
angustatum, *A. & S.*	645	III.	68
arundinaceum, *Schrad.*	912	III.	267
curvatum, *Fr.*	1290*	V.	131
elongatum, *Wahl.*	229	II.	216
hederæ, *De Not.*	231	II.	217
Neesii, *Duby*	913	III.	267
pulicare, *Pers.*	228	II.	216
repandum, *Blox.*	1186	V.	50
Rousselii, De Not.[1]	467	II.	349
virgultorum, *D.C.*	230	II.	216
xylomoides, *Chev.*	232	II.	217
Illosporium			
carneum, *Fr.*	891	III.	266
Isaria			
brachiata, *Schum.*	889	III.	266
Isothea			
pustula, *Berk.*	501	II.	350
Lachnea			
lapidaria, *Cooke*	1392*	VI.	194
Lachnella			
fragariastri, *Ph.*	1431	VI.	274
„ *Ph.*	1431	VI.	277
globulifera, *Fckl.*	1430	VI.	274
„ *Fckl.*	1430	VI.	277
grisella, *Rehm.*	1393	VI.	194
hinnulea, *B. & Br.*	1392	VI.	193
melaxantha, *Fr.*	1394	VI.	194
Lactarius			
acris, Fr.[2]	89	II.	212
blennius, *Fr.*	536	III.	62
camphoratus, *Fr.*	866	III.	264
chrysorrheus, *Fr.*	1268	V.	130
chrysorrheus, Fr.[3]	736	III.	135
deliciosus, *Fr.*	92	II.	212

[1] =*H. curvatum, Fr.*

[2] =*L. fuliginosus, Fr.*

[3] =*L. scrobiculatus, Fr.*

	NO.	VOL.	PAGE
Lactarius—*continued.*			
exsuccus, *Sm.*	332	II.	344
fuliginosus, *Fr.*	1408*	VI.	276
glyciosmus, *Fr.*	333	II.	344
hysginus, *Fr.*	735	III.	134
insulsus, *Fr.*	88	II.	212
mitissimus, *Fr.*	738	III.	135
pallidus, *Fr.*	865	III.	264
piperatus, *Fr.*	90	II.	212
pyrogalus, *Bull.*	1267	V.	129
quietus, *Fr.*	93	II.	212
scrobiculatus, *Fr.*	1055*	IV.	148
subdulcis, *Fr.*	1057	IV.	148
torminosus, *Fr.*	86	II.	212
trivialis, *Fr.*	1408	VI.	275
turpis, *Fr.*	87	II.	212
uvidus, *Fr.*	1056	IV.	148
vellereus, *Fr.*	91	II.	212
volemum, *Fr.*	737	III.	135
Lamproderma			
arcyrioides, *Somm.*	976	IV.	57
physarioides, *A. & S.*	763	III.	136
Lasiosphæria			
fulcita, *Bucknall*	1311	V.	126
„ *Bucknall*	1311	V.	132
innumera, *B. & Br.*	1017	IV.	60
ovina, *Pers.*	668	III.	69
scabra, *Curr.*	1310	V.	132
Lecythea			
lini, *Lev.*	984	IV.	57
saliceti, *Lev.*	983	IV.	57
valerianæ, *Berk.*	420	II.	347
Lentinus			
cochleatus, *Fr.*	1059	IV.	148
lepideus, *Fr.*	742	III.	135
Lenzites			
betulina, *Fr.*	342	II.	345
flaccida, *Fr.*	869	III.	264
Leocarpus			
fragilis, *Dicks.*	566	III.	64
Leotia			
lubrica, *Pers.*	215	II.	216

	NO.	VOL.	PAGE
Lepista			
nuda, Bull.	842*	III.	262
personata, Fr.	77	II.	211
Leptosphæria			
arundinacea, *var.* Godini, *Desm.*	1225	V.	53
Michotii, *West.*	1221*	V.	53
microscopica, *Karst.*	1223	V.	48
„ *Karst.*	1223	V.	53
nectrioides, *Speg.*	1222	V.	48
„ *Speg.*	1222	V.	53
vagabunda, *Sacc.*	1224	V.	48
„ *Sacc.*	1224	V.	53
Leptostroma			
phragmitis, *Fr.*	1378	VI.	189
„ *Fr.*	1378	VI.	191
Leptothyrium			
ribis, *Lib.*	979	IV.	57
Licea			
cylindrica, Fr.[1]	163	II.	214
Lophiostoma			
angustilabrum, *B. & Br.*	1015	IV.	59
arundinis, *De Not.*	1212	V.	52
bicuspidata, *Cooke*	482	II.	349
caulium, *Fr.*	1211	V.	52
compressum, *Pers.*	1213	V.	52
fibritectum, *Berk.*	1210	V.	52
montellicum, *Sacc.*	1307	V.	127
„ *Sacc.*	1307	V.	132
nucula, *Fr.*	1208*	V.	52
pulveracea, *Sacc.*	1208	V.	48
„ *Sacc.*	1208	V.	52
sexnucleatum, *Cooke*	1308	V.	132
vagabundum, *Sacc.*	1209	V.	48
„ *Sacc.*	1209	V.	52
vagans, *H. Fabre*	1309	V.	127
„ *H. Fabre*	1309	V.	132
Lophiotrema			
semiliberum, *Desm.*	1399	VI.	194
Lophium			
(Mytilidion) decipiens, *Karst.*	1115	IV.	200
fusisporum, *Cooke*	1005	IV.	59

---

[1] =*Clathroptychium rugulosum, Wallr.*

	NO.	VOL.	PAGE
Lophium—*continued.*			
mytilinum, *Fr.*	914	III.	268
Lycogala			
epidendrum, *Fr.*	154	II.	214
„ *Bux.*	571*	III.	64
Lycoperdon			
atro-purpureum, *Vitt.*	150	II.	214
cælatum, *Fr.*	149	II.	214
echinatum, *B. & Br.*	882	III.	266
gemmatum, *Fr.*	152	II.	214
giganteum, *Batsch.*	1348	VI.	32
pusillum, *Fr.*	1280	V.	130
pyriforme, *Schaeff.*	153	II.	214
saccatum, *Vahl.*	151	II.	214
Macrosporium			
concinnum, *Berk.*	593	III.	65
Marasmius			
amadelphus, *Fr.*	1099	IV.	199
androsaceus, *Fr.*	541	III.	62
epiphyllus, *Fr.*	104	II.	212
erythropus, *Fr.*	1413	VI.	276
fœtidus, *Fr.*	540	III.	62
fusco-purpureus, *Fr.*	1373	VI.	191
graminum, *B. & Br.*	103	II.	212
Hudsoni, *Fr.*	964	IV.	56
insititius, *Fr.*	339	II.	344
oreades, *Fr.*	100	II.	212
peronatus, *Fr.*	1058	IV.	148
porreus, *Fr.*	963	IV.	56
ramealis, *Fr.*	101	II.	212
rotula, *Fr.*	102	II.	212
urens, *Fr.*	741	III.	135
Massaria			
Curreyi, *Tul.*	1207	V.	52
eburnea, *Tul.*	1139	IV.	202
fœdans, *Fr.*	1205	V.	51
inquinans, *Tode*	1206	V.	52
pupula, *Fr.*	1138	IV.	202
siparia, *Tul.*	664	III.	69
Melampsora			
betulina, *Desm.*	413	II.	347

Melampsora—*continued.*	NO.	VOL.	PAGE
betulina, *Desm.*	587	III.	65
euphorbiæ, *Cast.*	414	II.	347
hypericorum, *D.C.*	1386	VI.	193
Melanconis			
alni, *Tul.*	1297	V.	131
chrysostoma, *Tul.*	657	III.	69
lanciformis, *Tul.*	820	III.	138
stilbostoma, *Tul.*	253	II.	217
thelebola, *Fr.*	1298	V.	131
Melanconium			
bicolor, *Nees.*	170	II.	214
sphærospermum, *Link.*	887	III.	266
typhæ, *Peck*	1178	V.	47
,, *Peck*	1178	V.	50
Melanomma			
fuscidulum, *Sacc.*	1219	V.	52
Merulius			
corium, *Fr.*	119	II.	213
lacrymans, *Fr.*	1375	VI.	191
pallens, *Berk.*	352	II.	345
tremellosus, *Schrad.*	1374	VI.	191
Metasphæria			
corticola, *Sacc. & Speg.*	1225*	V.	53
Mitrula			
paludosa, *Fr.*	1111	IV.	200
Mollisia			
arundinacea, *D.C.*	1389	VI.	193
dilutella, *Fr.*	1391	VI.	193
discolor, *Mont.*	1388*	VI.	193
palustris, *Rob. var.*	1390	VI.	193
Monotospora			
megalospora, *B. & Br.*	201	II.	215
Morchella			
crassipes, *Pers.*	601	III.	66
esculenta, *Linn.*	1428	VI.	277
semilibera, *D.C.*	444	II.	348
Mucor			
caninus, *Pers.*	1071	IV.	149
fusiger, *Link.*	212	II.	216
Myrothecium			
roridum, *Tode*	1670	IV.	148

	NO.	VOL.	PAGE
Næmatelia			
virescens, *Corda*	761	III.	135
Nectria			
arenula, *B. & Br.*	916	III.	268
cinnabarina, *Fr.*	471	II.	349
coccinea, *Fr.*	472	II.	349
dacrymycella, *Nyl.*	1007	IV.	59
episphæria, *Fr.*	646	III.	68
erubescens, *Desm.*	817	III.	138
mammoidea, *P. & Ph.*	915	III.	268
peziza, *Fr.*	473	II.	349
pulicaris, *Tul.*	238	II.	217
punicea, *Schm.*	1362	VI.	33
Russeliana, *Mont.*	1006	IV.	59
sanguinea, *Fr.*	239	II.	217
Nemaspora			
crocea, *Pers.*	771	III.	136
Nematogonum			
aurantiacum, *Desm.*	206	II.	216
Neottiospora			
caricum, *Desm.*	981	IV.	57
Nummularia			
Bulliardi, *Tul.*	249	II.	217
Nyctalis			
parasitica, *Fr.*	868	III.	264
Octaviana			
compacta, *Tul.*	560	III.	63
Odontia			
fimbriata, *Pers.*	965	IV.	56
stipata, *Fr.*	357	II.	345
,, *Fr.*		II.	350
Ohleria			
obducens, *Winter*	1219*	V.	52
Oidium			
fructigenum, *Schrad.*	440	II.	348
fulvum, *Link.*	439	II.	348
Oligonema			
furcatum, *Bucknall*	1419	VI.	274
,, *Bucknall*	1419	VI.	276
nitens, *Rost.*	1382	VI.	189
,, *Rost.*	1382	VI.	192

	NO.	VOL.	PAGE
Ombrophila			
clavus, *A. & S.*	1361	VI.	33
Ophiobolus			
herpotrichus, *Fr.*	1398	VI.	194
urticæ, *Rabh.*	1231	V.	54
vulgaris, *Sacc.*	1232	V.	54
Ophiotheca			
umbrina, *Berk.*		VI.	276
Pachnocybe			
subulata, *Berk.*	589	III.	65
Panus			
stypticus, *Fr.*	341	II.	345
torulosus, *Fr.*	340	II.	345
Patellaria			
atrata, *Fr.*	633	III.	68
connivens, *Fr.*	1185	V.	50
lignyota, *Fr.*	636	III.	68
olivacea, *Batsch.*	635	III.	68
parvula, *Cooke*	1290	V.	130
proxima, *B. & Br.*	634	III.	68
Paxillus			
involutus, *Fr.*	78	II.	211
lepista, *Fr.*	1097	IV.	199
lividus, *Cooke*	1334	VI.	28
„ *Cooke*	1334	VI.	31
panæolus, *Fr.*	957	IV.	56
„ *Fr.*	1097*	IV.	199
panuoides, *Fr.*	730	III.	134
Penicillium			
crustaceum, *Fr.*	209	II.	216
„ *var.* coremium	209*	II.	216
subtile, *Berk.*	210	II.	216
Peniophora			
velutina, *Cooke*	1417	VI.	276
Perichæna			
confusa, *Massee*	1420	VI.	276
corticalis, *Batsch.*	977	IV.	57
depressa, *Lib.*	1383	VI.	193
variabilis, Rost.	1420	VI.	276
Perisporium			
vulgare, *Corda*	1291*	V.	131

	NO.	VOL.	PAGE
Peronospora			
candida, *Fckl.*	436	II.	348
infestans, *Mont.*	434	II.	347
obliqua, *Cooke*	437	II.	348
parasitica, *Pers.*	435	II.	348
Pestalozzia			
lignicola, *Cooke*	1284	V.	130
Peziza			
acetabulum, *Linn.*	1112	IV.	200
acetabulum Linn.[1]	446	II.	348
Adæ, *Sadler*	1357	VI.	33
apala, *B. & Br.*	795	III.	137
araneo-cincta, *Ph.*	621	III.	67
arctii, *Ph.*	999	IV.	58
aspidiicola, *B. & Br.*	620	III.	67
atrata, *Pers.*	625	III.	67
atro-virens, *Pers.*	907	III.	267
aurantia, *Fr.*	791	III.	137
badia, *Pers.*	447	II.	348
bicolor, *Bull.*	613	III.	66
brunnea, *A. & S.*		IV.	149
brunneola, *Desm.*	616	III.	67
calycina, *Schum.*	218	II.	216
cerea, *Sow.*	1358	VI.	33
cerina, *Pers.*	614	III.	66
cinerea, *Batsch.*	223	II.	216
„ *var.* fallax, *Desm.*	906	III.	267
coccinea, *Jacq.*	450	II.	348
cochleata, *Huds.*	216	II.	216
corticalis, *Pers.*	902	III.	267
Crouani, *Cooke*	899	III.	267
cupularis, *Linn.*	609	III.	66
Curreiana, *Tul.*	801	III.	137
cyathoidea, *Bull.*	457*	II.	348
domestica, *Sow.*	622	III.	67
echinulata, *Awd.*	796	III.	137
erumpens, *Grev.*	624	III.	67
excelsior, *Karst.*	998	IV.	58
fibrillosa, *Curr.*	1288	V.	130
filicea, *C. & Ph.*	904	III.	267
firma, *Pers.*	457	II.	348

---

[1] *P. leucomelas, Pers.*

Peziza—*continued.*	NO.	VOL.	PAGE
fugiens, *Bucknall*	800	III.	137
furfuracea, *Fr.*	1184	V.	50
fusarioides, *Berk.*	460	II.	348
fusca, *Pers.*	905	III.	267
granulata, *Bull.*	610	III.	66
gregaria, *Rehm.*	900	III.	267
„ *Rehm.*		IV.	149
hæmastigma, *Fr.*	1113	IV.	200
hemisphærica, *Wigg.*	451	II.	348
hepatica, *Batsch.*	908	III.	267
humosa, *Fr.*	792	III.	137
hyalina, *Pers.*	456	II.	348
hybrida, *Sow.*[1]	1074	IV.	149
inflatula, *Karst.*	626	III.	67
inflexa, *Bolt.*	1289	V.	130
lapidaria, *Cooke*	1359*	VI.	28
„ *Cooke*	1359*	VI.	33
leporina, *Batsch.*	790	III.	137
leucomelas, *Pers.*	1112*	IV.	200
luzulina, *Ph.*	1360	VI.	23
macrocystis, *Cooke*	794	III.	137
macropus, *Pers.*	605	III.	66
melaloma, *A. & S.*	1359	VI.	33
melastoma, *Sow.*	1114	IV.	200
micacea, *Pers.*	799	III.	137
misturæ, *Ph.*	611	III.	66
nivea, *Fr.*	996	IV.	58
omphalodes, *Bull.*	793	III.	137
onotica, *Pers.*	1073	IV.	149
palearum, *Desm.*	797	III.	137
pellita, *Pers.*	619	III.	67
polytrichi, *Schum.*	1427	VI.	277
prasina, *Quel.*	997	IV.	58
pulla, *Ph. & K.*	628	III.	68
punctoidea, *Karst.*	627	III.	67
pygmæa, *Fr.*	995	IV.	58
repanda, *Wahl.*	448	II.	348
reticulata, *Grev.*	606	III.	66
rhabdosperma, *B. & Br.*	221	II.	216
rhytismæ, *Ph.*	901	III.	267

---

[1] =*P. lapidaria, Cooke.*

Peziza—*continued.*	NO.	VOL.	PAGE
rutilans, *Fr.*	993	IV.	58
Schumacheri, *var.* plumbea, *Fr.*	615	III.	67
scutellata, *Lirn.*	453	II.	348
solfatera, *C. & E.*	618	III.	67
stercorea, *Pers.*	454	II.	348
straminum, *B. & Br.*	798	III.	137
striata, *Fr.*[1]	222	II.	216
subhirsuta, *Schum.*	449	II.	348
succosa, *Berk.*	607	III.	66
sulphurea, *Pers.*	219	II.	216
„ *var.* leucophæa, *Pers.*	903	III.	267
tectoria, *Cooke*	1387	VI.	193
trechispora, *B. & Br.*	452	II.	348
trichodea, *Ph.*	617	III.	67
umbrata, *Fr.*	612	III.	66
„ *Fr.*		IV.	149
variecolor, *Fr.*	455	II.	348
venosa, *var.* ancilis, *Rehm.*	1183	V.	50
vesiculosa, *Bull.*	608	III.	66
villosa, *Pers.*[2]	220	II.	216
vinosa, *A. & S.*	623	III.	67
violascens, *Cooke*	994	IV.	58
virginea, *Batsch.*	217	II.	216
viridaria, *B. & Br.*	891	III.	267
vulgaris, *Fr.*	459	II.	348
„ *Fr.*		VI.	193
xanthostigma, *Fr.*	458	II.	348
Phacidium			
pini, *Schum.*	911	III.	267
ranunculi, *Desm.*	1004	IV.	59
repandum, *Fr.*	1077	IV.	150
Phallus			
impudicus, *Linn.*	1279	V.	130
Phlebia			
merismoides, *Fr.*	1275	V.	130
radiata, *Fr.*	1276	V.	130
vaga, *Fr.*	554	III.	63
Phlyctæna			
vagabunda, *Desm.*	395	II.	346

---

[1] =*P. cyathoidea, Bull.*

[2] =*Cyphella villosa, Pers.*

	NO.	VOL.	PAGE
Phoma			
concentricum, *Desm.*	575	III.	65
equiseti, *Lev.*	978	IV.	57
exiguum, *Desm.*	166	II.	214
hederæ, *Desm.*	164	II.	214
melæna, *Fr.*	1283	V.	130
nebulosum, *Berk.*	392	II.	346
samarorum, *Desm.*	165	II.	214
Phragmidium			
acuminatum, *Fr.*	399	II.	346
bulbosum, *Schl.*	178	II.	215
mucronatum, *Link.*	398	II.	346
obtusum, *Link.*	179	II.	215
Physarum			
cinereum, *Batsch.*	562*	III.	63
leucophæum, *Fr.*	563	III.	63
metallicum, *Berk.*	157	II.	214
Schumacheri, *Spr.*	1349	VI.	32
Pilacre			
Petersii, *Berk. & Curt.*	598	III.	65
Pilobolus			
crystallinus, *Tode*	442	II.	348
Pirottæa			
veneta, *Sacc.*	1395	VI.	189
„ *Sacc.*	1395	VI.	194
Pistillaria			
micans, *Fr.*	881	III.	266
quisquilaris, *Fr.*	970	IV.	57
Pleospora			
rubicunda, *Niessl.*	1229	V.	53
vagans, *Niessl.*	1230	V.	48
„ *Niessl.*	1230	V.	54
vulgaris, *Niessl.*	1228	V.	53
Polyactis			
cana, *Berk.*	207	II.	216
cinerea, *Berk.*	438	II.	348
fascicularis, *Corda*	208	II.	216
Polyporus			
abietinus, *Fr.*	117	II.	213
adustus, *Fr.*	344	II.	345
annosus, *Fr.*	115	II.	213
applanatus, *F.*	873	III.	265

Polyporus—*continued.*	NO.	VOL.	PAGE
betulinus, *Fr.*	112	II.	213
borealis, *Fr.*	752	III.	135
cæsius, *Fr.*	1060	IV.	148
chioneus, *Fr.*	544	III	62
conchatus, *Fr.*	1061	IV.	148
connatus, *Fr.*	753	III.	135
cuticularis, *Fr.*	1161	V.	49
dryadeus, *Fr.*	345	II.	345
ferruginosus, *Fr.*	346	II.	345
fomentarius, *Fr.*	113	II.	213
fragilis, *Fr.*	343	II.	345
fraxineus, *Fr.*	545	III.	62
fumosus, *Fr.*	1270	V.	130
giganteus, *Fr.*	110	II.	112
hispidus, *Fr.*	111	II.	212
igniarius, *Fr.*	1343	VI.	32
intybaceus, *Fr.*	1160	V.	49
lentus, *Berk.*	872	III.	264
lucidus, *Fr.*	1342	VI.	31
melanopus, *Fr.*	749	III.	135
micans, *Fr.*	347	II.	345
molluscus, *Fr.*	753*	III.	135
molluscus, Fr.[1]	350	II.	345
obducens, *Pers.*	348	II.	345
perennis, *Fr.*	1341	VI.	31
picipes, *Fr.*	1415	VI.	276
purpureus, *Fr.*	874	III.	265
radula, *Fr.*	875	III.	265
ribis, *Fr.*	1100	IV.	199
spumeus, *Fr.*	1271	V.	130
squamosus, *Fr.*	543	III.	62
sulphureus, *Fr.*	751	III.	135
ulmarius, *Fr.*	114	II.	213
Vaillantii, *Fr.*	1344	VI.	32
vaporarius, *Fr.*	754	III.	135
varius, *Fr.*	750	III.	135
versicolor, *Fr.*	116	II.	213
vulgaris, *Fr.*	349	II.	345
Polythrincium			
trifolii, *Kütz.*	433	II.	347

[1] =*P. vaporarius, Fr.*

	NO.	VOL.	PAGE
Poronia			
punctata, *Fr.*	1397	VI.	194
Pseudhelotium			
deparculum, Kars	1429	VI.	277
Pseudovalsa			
fusca, *Bucknall*	1198	V.	46
„ *Bucknall*	1198	V.	51
Psilonia			
gilva, *Fr.*	987	IV.	58
Psilosphæria			
dioica, *Moug.*	1313	V.	132
mammiformis, *Pers.*	1312	V.	132
obducens, *Fr.*	1215	V.	52
pulveracea, *Ehr.*	667	III.	69
pulviscula, *Curr.*	1214	V.	52
Stevensoni, *B. & Br.*	1016	IV.	60
Puccinia			
adoxæ, *D.C.*	405	II.	347
anemones, *Pers.*	402	II.	346
arundinacea, *Hedw.*	584	III.	65
betonicæ, *D.C.*	181	II.	215
bullata, *Pers.*	1385	VI.	193
buxi, *D.C.*	982	IV.	57
circeæ, *Pers.*	187	II.	215
compositarum, *Sch.*	182	II.	215
coronata, *Corda*	400	II.	346
„ *Corda*	1423	VI.	277
galii, *Pers.*	1384	VI.	193
glechomatis, *D.C.*	401	II.	346
graminis, *Pers.*	772	III.	136
lychnidearum, *Link.*	186	II.	215
malvacearum, *Corda*	183	II.	215
menthæ, *Pers.*	1421	VI.	277
mixta, *Fckl.*	1285	V.	130
polygonorum, *Link.*	585	III.	65
primulæ, *Grev.*	773	III.	136
pruni, *Pers.*	1422	VI.	277
pulverulenta, *Grev.*	406	II.	347
saniculæ, *Grev.*	184	II.	215
smyrnii, *Corda*	185	II.	215
striola, *Link.*	180	II.	215
tripolii, *Wallr.*	1181	V.	50

Puccinia—*continued.*	NO.	VOL.	PAGE
umbilici, *Guep.*	404	II.	347
vincæ, *Berk.*	1353	VI.	32
violarum, *Link.*	403	II.	347
Pyrenophora			
calvescens, *Fr.*	1239	V.	54
phæcomoides, *Sacc.*	1238	V.	54
Radulum			
quercinum, *Fr.*	355	II.	345
Reticularia			
lycoperdon, *Bull.*	568*	III.	64
maxima, *Fr.*	376	II.	346
umbrina, *Fr.*	155	II.	214
Rhopalomyces			
pallidus, *B. & Br.*	441	II.	348
Rhytisma			
acerinum, *Fr*	227	II.	216
Russula			
adusta, *Fr.*	95	II.	212
alutacea, *Fr.*	338	II.	344
aurata, *Fr.*	1337	VI.	31
cærulea, *Pers.*	1409	VI.	276
chamæleontina, *Fr.*	739	III.	135
consobrina, *Fr.*	1158	V.	49
cyanoxantha, *Fr.*	1336	VI.	31
cyanoxantha, *Fr.*	97	II.	212
emetica, *Fr.*	538	III.	62
fellea, *Fr.*	1269	V.	130
fœtens, *Fr.*	98	II.	212
fragilis, *Fr.*	337	II.	344
furcata, *Fr.*	537	III.	62
granulosa, *Cooke*	1411	VI.	276
heterophylla, *Fr.*	335	II.	344
integra, *Fr.*	867	III.	264
nigricans, *Fr.*	94	II.	212
nitida, *Fr.*[1]	1098	IV.	199
ochracea, *A. & S.*	1338	VI.	31
ochroleuca, *Fr.*	336	II.	344
puellaris, *Fr.*	1412	VI.	276
pulchralis, *Britz.*	1337*	VI.	28

---

[1] =*R. pulchralis*, *Britz.*

	NO.	VOL.	PAGE
Russula—*continued.*			
pulchralis, *Britz.*	1337*	VI.	31
purpurea, *Gillet*	1335*	VI.	31
Queletii, *Fr.*	537*	III.	62
rubra, *var.* sapida, *Cooke*	1410	VI.	276
rubra, Fr.[1]	96	II.	212
sardonia, *Fr.*	1335	VI.	31
virescens, Fr.[2]	334	II.	344
Ryparobius			
dubius, *Boud.*	465	II.	349
Schizophyllum			
commune, *Fr.*	743	III.	135
Scleroderma			
verrucosum, *Pers.*	375	II.	346
vulgare, *Fr.*	374	II.	346
Sepedonium			
chrysospermum, *Link.*	597	III.	65
Septonema			
elongatispora, *Preuss*	176	II.	215
Septoria			
aceris, *B. & Br.*	886	III.	266
atriplicis, *West.*	1177	V.	50
hederæ, *Desm.*	168	II.	214
medicaginis, *Rob. & Desm.*	1175	V.	47
,, *Rob. & Desm.*	1175	V.	50
primulæ, *Bucknall*	1176	V.	50
scabiosæcola, *Desm.*	393	II.	346
Sistotrema			
confluens, *Pers.*	354	II.	345
Solenia			
ochracea, *Hoffm.*	367	II.	345
Sordaria			
bisporula, *Hans.*	827	III.	138
caudata, *Curr.*	925	III.	268
coprophila, *Fr.*	669	III.	69
curvula, *D. By.*	824	III.	138
fimicola, *Rob.*	924	III.	268
lanuginosa, *Fr.*	1217	V.	52
merdaria, *Fr.*	822	III.	138
microspora, *Ph. & Pl.*	927	III.	269

---

[1] =*Queletii, Fr.*

[2] =*R. furcata, Fr.*

Sordaria—*continued.*	NO.	VOL.	PAGE
minuta, *var.* tetraspora, *Winter*	823	III.	138
platyspora, *Ph. & Pl.*	670	III.	69
pleiospora, *Winter*	825	III.	138
polyspora, *Ph. & Pl.*	928	III.	269
sparganicola, *Pl.*	926	III.	268
,, *var.* velata, *Bucknall.*	1216	V.	46
,, ,, ,, *Bucknall.*	1216	V.	52
Winteri, *Ph. & Pl.*	826	III.	138
Sphærella			
carpinea, *Fr.*	687	III.	70
errabunda, *Gonn. & Rabh.*	688	III.	70
fagi, *Auersw.*	1234	V.	54
hederæ, *Sow.*	268	II.	218
inæqualis, *Cooke*	497	II.	350
juncina, *Auersw.*	1236	V.	54
latebrosa, *Cooke*	686	III.	70
maculiformis, *Pers.*	496	II.	350
oblivia, *Cooke*	685	III.	70
punctiformis, *Pers.*	1233	V.	54
rumicis, *Desm.*	267	II.	218
rusci, *De Not.*	266	II.	218
Tassiana, *De Not.*	1235	V.	48
,, *De Not.*	1235	V.	54
taxi, *Cooke*	498	II.	350
Sphæria			
acuminata, *Sow.*	262	II.	217
acuta, *Moug.*	263	II.	217
agnita, *Desm.*	680	III.	69
alliariæ, *Awd.*	265	II.	218
appendiculosa, *B. & Br.*	677	III.	69
arundinacea, *Sow.*	1082	IV.	150
capillifera, *Curr.*	484	II.	349
cariceti, *B. & Br.*	932	III.	270
clivensis, *B. & Br.*	491	II.	349
clypeata, *Nees.*	832	III.	139
complanata, *Tode*	681	III.	70
conoidea, *Niessl.*	1316*	V.	132
corticola, *Fckl.*	1143	IV.	203
culmicola, *Fr.*	1319[1]	V.	128
,, *Fr.*	1318	V.	132

[1] *For* 1319 *read* 1318.

Sphæria—*continued.*	NO.	VOL.	PAGE
culmifida, *Karst.*	1321[1]	V.	128
,, *Karst.*	1320	V.	132
culmifraga, *Fr.*	1023	IV.	60
cumana, *Sacc. & Speg.*	1144	IV.	203
cupulifera, *B. & Br.*	483	II.	349
decedens, *Fr.*	829	III.	138
deflectens, *Karst.*	929	III.	269
ditopa, *Fr.*	1019	IV.	60
dolioides, *Auers.*	1320[2]	V.	128
,, *Auers.*	1319	V.	132
doliolum, *Pers.*	493	II.	349
endopteris, *Pl.*	931	III.	269
equorum, *Winter*	488	II.	349
felina, *Fckl.*	923	III.	268
fraxinicola, *Curr.*	674	III.	69
galiorum, *Sacc.*	1318[3]	V.	128
,, *Sacc.*	1317	V.	132
graminis, *Fckl.*	933	III.	270
herbarum, *Pers.*	261	II.	217
hirsuta, *Fr.*	482*	II.	349
hispida, Tode[4]	257	II.	217
infectoria, *Fckl.*	684	III.	70
,, *Fckl.*	836	III.	139
inquilina, *Fr.*	260	II.	217
italicum, *Sacc.*	1018	IV.	60
ligneola, *B. & Br.*	489	II.	349
Marram, *Cooke*	1084	IV.	150
Michotii, *West*	834	III.	139
millepunctata, *Grev.*	675	III.	69
Montagnei, *Dur. & Mont.*	1317[5]	V.	128
,, *Dur. & Mont.*	1316	V.	132
nardi, *Fr.*	835	III.	139
nigrans, *Desm.*	682	III.	70
Ogilviensis, *B. & Br.*	1021	IV.	60
ostioloidea, *Cooke*	259	II.	217
palustris, *B. & Br.*	678	III.	69
pellita, *Fr.*	264	II.	218
perexigua, *Curr.*	486	II.	349
phæosticta, *Berk.*	1020	IV.	60

---

[1] *For* 1321 *read* 1320.
[2] *For* 1320 *read* 1319.
[3] *For* 1318 *read* 1317.
[4] *=Sp. hirsuta, Fr.*
[5] *For* 1317 *read* 1316.

Sphæria—*continued.*	NO.	VOL.	PAGE
phæostroma, *Mont.*	256	II.	217
planiuscula, *B. & B*	495	II.	350
Plowrightii, *Niessl.*	1315	V.	132
pomiformis, Pers.[1]	485	II.	349
pulvis-pyrius, *Pers.*	487	II.	349
quadrinucleata, *Curr.*	830	III.	138
rhodobapha, *B. & Br.*	930	III.	269
rostellata, Fr.[2]	1083	IV.	150
rubella, *Pers.*	492	II.	349
rubelloides, *Plow.*	1022	IV.	60
sæpincoliformis, *De Not.*	1142	IV.	202
salicella, *Fr.*	676	III.	69
scirpicola, *D.C.*	831	III.	139
spermoides, *Hoffm.*	258	II.	217
superflua, *Awd.*	494	II.	350
tosta, *B. & Br.*	683	III.	70
typhæcola, *Cooke*	934	III.	270
ulnaspora, *Cooke*	679	III.	69
uni-caudata, *B. & Br*	1141	IV.	202
vectis, *B. & Br.*	833	III.	139
verecunda, *Curr.*	490	II.	349
Sphærobolus			
stellatus, *Tode*	767	III.	136
Sphæronema			
vitreum, *Corda*	768	III.	136
Sphærotheca			
pannosa, *Lev.*	599	III.	66
Sphærulina			
intermixta, *var.* Corni, *B. & Br.*	1226	V.	53
Sporidesmium			
lepraria, *B. & Br.*	177	II.	215
Sporochisma			
mirabile, *B. & Br.*	397	II.	346
Sporocybe			
albipes	428	II.	347
byssoides, *Fr.*	200	II.	215
Sporodinia			
dichotoma, *Corda*	988	IV.	58
Sporormia			
intermedia, *Awd.*	671	III.	69

[1] = *Ohleria obducens, Winter.*

[2] = *Valsa nidulans, Niessl.*

	NO.	VOL.	PAGE
Sporormia—*continued.*			
secedens, Bucknall[1]	1218	V.	46
„ *Bucknall*	1218	V.	52
Spumaria			
alba, *D.C.*	377	II.	346
„ *Bull.*	567*	III.	64
Stagonospora			
aquatica, *var.* junciseda, *Sacc.*	1171	V.	47
„ „ *Sacc.*	1171	V.	50
gigaspora, *Niessl.*	1172	V.	47
„ *Niessl.*	1172	V.	50
typhoidearum, *Desm.*	1170	V.	50
Stegia			
ilicis, *Fr.*	468	II.	349
Stemonitis			
ferruginea, *Ehr.*	1282	V.	130
fusca, *Roth.*	383	II.	346
„ *Roth.*	567*	III.	64
obtusata, *Fr.*	384	II.	346
typhoides, D.C.	159	II.	214
Stereum			
hirsutum, *Fr.*	126	II.	213
purpureum, *Fr.*	125	II.	213
rugosum, *Fr.*	129	II.	213
sanguinolentum, *Fr.*	128	II.	213
spadiceum, *Fr.*	127	II.	213
Stictis			
Berkleyana, *Du R. & Lev.*	910	III.	267
pteridina, *Ph. & Buck.*	1002	IV.	58
versicolor, *Fr.*	643	III.	68
Stigmatea			
geranii, *Fr.*	499	II.	350
ranunculi, *Fr.*	500	II.	350
Robertiani, *Fr.*	270	II.	218
Stilbum			
erythrocephalum, *Ditm.*	1354	VI.	32
rigidum, *Pers.*	198	II.	215
tomentosum, *Schrad.*	197	II.	215
Stysanus			
stemonitis, *Corda*	211	II.	216
Synchytrium			
taraxaci, *De By. & Wor.*	1110	IV.	200

---

[1] = *Perisporium vulgare, Corda.*

	NO.	VOL.	PAGE
Tetraploa			
aristata, *B. & Br.*	1180	V.	50
Thelephora			
anthocephala, *Fr.*	357*	II.	345
arida, *Fr.*	1102	IV.	200
cæsia, *Pers.*	1101	IV.	200
fastidiosa, *Fr.*	124	II.	213
laciniata, *Pers.*	553*	III.	63
laxa, *Fr.*	360	II.	345
mollissima, *Pers.*	877	III.	265
mollissima, *Pers.*[1]	358	II.	345
sebacea, *Pers.*	359	II.	345
Sowerbei, *Berk.*	1277	V.	130
Tilmadoche			
mutabilis, *Rost.*	567	III.	64
nutans, *Pers.*	566*	III.	64
Torrubia			
militaris, *Fr.*	234	II.	217
Torula			
abbreviata, *var.* sphæriformis, *B. & Br.*	1179	V.	50
herbarum, *Link.*	174	II.	214
hysterioides, *Corda*	173	II.	214
pulveracea, *Corda*	172	II.	214
Trametes			
gibbosa, *Fr.*	351	II.	345
mollis, *Sommf.*	1272	V.	130
serpens, *Fr.*	547	III.	63
Stephensii, *B. & Br.*	548	III.	63
suaveolens, *Fr.*	546	III.	63
Tremella			
albida, *Hud.*	145	II.	214
epigæa, *B. & Br.*	559	III.	63
mesenterica, *Retz.*	144	II.	214
torta, *Berk.*	372	II.	346
tubercularia, *Berk.*	1278	V.	130
Trichia			
cerina, *Ditm.*	387	II.	346
chrysosperma, *D.C.*	390	II.	346
chrysosperma, *Bull.*	765	III.	136
contorta, *Rost.*	1351	VI.	32
„ *Rost.*	1380*	VI.	192

---

[1] =*Th. laciniata*, *Pers.*

	NO.	VOL.	PAGE
Trichia—*continued.*			
fallax, *Pers.*	162	II.	214
„ *Pers.*	571*	III.	64
nigripes, *Pers.*	388	II.	346
scabra, *Rost.*	572	III.	64
turbinata, *With.*	389	II.	346
varia, *Pers.*	391	II.	346
„ *Pers.*	571*	III.	64
„ *var.* nigripes	764	III.	136
Trichobasis			
iridis, *Cooke*	419	II.	347
oblongata, *Berk.*	417	II.	347
petroselini, *Berk.*	193	II.	215
suaveolens, *Lev.*	418	II.	347
symphyti, *Lev.*	192	II.	215
ulmariæ, *Cooke*	776	III.	136
Trisporium			
elegans, *Corda*	204	II.	216
Trochila			
craterium, *Fr.*	233	II.	217
laurocerasi, *Fr.*	1187	V.	50
Tuber			
puberulum, *B. & Br.*	466	II.	349
Tuberculina			
persicina, *Sacc.*	1356	VI.	32
Tympanis			
fraxini, *Schum.*	637	III.	68
Typhula			
erythropus, *Desm.*	558	III.	63
Grevillei, *Fr.*	143	II.	213
gyrans, *Fr.*	969	IV.	57
Uncinula			
bicornis, *Lev.*	443	II.	348
Uredo			
bifrons, *Grev.*	416	II.	347
confluens, *D.C.*	415	II.	347
Urocystis			
pompholygodes, *Schlect.*	408	II.	347
Uromyces			
apiculosa, *Lev.*	409	II.	347

	NO.	VOL.	PAGE
Uromyces—*continued.*			
concentrica, *Lev.*	411	II.	347
ficariæ, *Lev.*	410	II.	347
Ustilago			
antherarum, *Fr.*	407	II.	347
carbo, *Tul.*	774	III.	136
longissima, *Tul.*	775	III.	136
receptaculorum, *Fr.*	1424	VI.	277
tragopogi, *Pers.*	1424	VI.	277
Ustulina			
vulgaris, *Tul.*	243	II.	217
Valsa			
abietis, *Fr.*	1133	IV.	201
aceris, *Fckl.*	1294	V.	131
aglæostoma, *B. & Br.*	1135	IV.	202
ambiens, *Fr.*	660	III.	69
angustata, *Fckl.*	1136	IV.	202
betulæ, *Tul.*	1137	IV.	202
ceratophora, *Tul.*	659	III.	69
circumscripta, *Mont.*	663	III.	69
controversa, *Fr.*	658	III.	69
cornicola, *Cooke*	1293	V.	131
coronata, *Fr.*	1131	IV.	201
Curreyi, *Nits.*	1132	IV.	201
detrusa, *Fr.*	1295	V.	131
dissepta, *Fr.*	821	III.	138
fenestrata, *B. & Br.*	1199	V.	51
gastrinoides, *P. & P*	922	III.	268
gregaria, *Lib.*	1193	V.	47
„ *Lib.*	1193	V.	51
hippocastani, *Cooke*	1197	V.	51
hypodermia, *Fr.*	1195	V.	51
hystrix, *Sacc.*	1081	IV.	150
Inessii, *Curr.*	1296	V.	131
leiphemia, *Fr.*	662	III.	69
microstoma, *Fr.*	1130	IV.	201
nidulans, *Niessl.*	1197*	V.	47
„ *Niessl.*	1197*	V.	51
nivea, *Hoffm.*	1194	V.	51
platanoides, *Berk.*	921	III.	268
pulchella, *Fr.*	255	II.	217

	NO.	VOL.	PAGE
Valsa—*continued.*			
pustulata, *Desm.*	1013	IV.	59
quaternata, *Fr.*	661	III.	69
rhodophila, *B. & Br.*	919	III.	268
salicina, *Fr.*	1134	IV.	201
stellatula, *Fr.*	1128	IV.	201
suffusa, *Fr.*	1196	V.	51
syngenesia, *Fr.*	1129	IV.	201
taleola, *Fr.*	920	III.	268
tetraploa, *Berk. & Curt.*	254	II.	217
tiliæ, *Tul.*	1012	IV.	59
Venturia			
ditricha, *Fr.*	1237	V.	54
inæqualis, *Cooke*	1237*	V.	54
Vermicularia			
dematium, *Fr.*	885	III.	266
trichella, *Grev.*	1105	IV.	200
Vibrissea			
turbinata, *Ph.*	602	III.	66
Volutella			
ciliata, *Fr.*	1426	VI.	277
hyacinthorum, *Berk.*	1355	VI.	32
melaloma, *B. & Br.*	890	III.	266
setosa, *Berk.*	985	IV.	58
Xylaria			
carpophila, *Fr.*	242	II.	217
digitata, *Grev.*	647	III.	68
hypoxylon, *Grev.*	241	II.	217
polymorpha, *Grev.*	240	II.	217
Xylosphæria			
apiculata, *Curr.*	1140	IV.	202
hemitapha, *B. & Br.*	828	III.	138
melanotes, *B. & Br.*	673	III.	69
Zignoella			
seriata, *Curr.*	1221	V.	53
Zygodesmus			
fuscus, *Corda*	897	III.	267

INDEX TO PLATES.

	VOL.	PLATE.	FIG.
Agaricus			
Bucknalli, *B. & Br.*	III.	I.	2
electicus, *Bucknall*	III.	II.	2, 3
formosus. *Fr.*	III.	I.	3
granulosus, *var.* rufescens, *B. & Br.*	III.	II.	1
hispidulus, *Fr.*	III.	I.	2
lineatus, *Bull.*	III.	I.	1
muricatus, *var.* gracilis, *Quel.*	III.	III.	1
sarcocephalus, *Fr.*	III.	III.	3
vestitus, *Fr.*	III.	III.	2
Apiospora			
Montagnei, *Dur. & Mont.*	V.	XIII.	10
Ceriospora			
xantha, *Sacc.*	V.	VIII.	17
Chætodiplodia			
caulina, *Karst.*	V.	V.	5
Clavaria			
aculina, *Quel.*	IV.	I.	1
Cortinarius			
arvinaceus, *Fr.*	IV.	V.	1
cotoneus, *Fr.*[1]	III.	I.	4
croceo-cæruleus, *Pers.*	IV.	III.	3
firmus, *Fr.*	III.	I.	1
macropus, *Fr.*	IV.	IV.	1
papulosus, *Fr.*	IV.	III.	1
quadricolor, *Fr.*[2]	IV.	V.	2
Cribaria			
microcarpa, *Rost.*	VI.	I.	3
Cryptovalsa			
Nitschkei, *Fckl.*	V.	XI.	1

---

[1] Probably *C. sublanatus*, *Fr.*

[2] =*C. bicolor* *Cooke.*

	VOL.	PLATE.	FIG.
Cyppella			
Curreyi, *B. & M.*	III.	II.	1
faginea, *Lib.*	III.	II.	3
villosa, *Pers.*	III.	II.	2
Diaporthe			
crustosa, *Sacc. & Roum.*	V.	XII.	5
discrepans, *Sacc.*	V.	XI.	3
quercus, *Fckl.*	V.	XI.	4
Tulasnei, *Nke.*	V.	XI.	2
Didymella			
sæpincoliformis, *De Not.*	V.	VIII.	21
Didymosphæria			
conoidea, *Niessl.*	V.	XIII.	11
Dothidea			
caricis, *Fr.*	IV.	I.	8
Helminthosporium			
folliculatum, *var. B. Corda*	III.	II.	5
Helotium			
flavum, *Klotsch.*	III.	IV.	3
Hemiarcyria			
Bucknalli, *Massee.*	VI.	II.	5
Hendersonia			
graminicola, *Lev.*	III.	II.	6
hapalocystis, *Cooke*	VI.	I.	2
phragmitis, *Desm.*	V.	VI.	7
riparia, *Sacc.*	V.	VI.	6
Hypospila			
viburni, *Bucknall*	V.	VIII.	20
Hysterium			
Neesii, *Duby.*	III.	II.	8
Lachnea			
lapidaria, *Cooke*	VI.	II.	7
Lachnella			
grisella, *Rehm.*	VI.	II.	8
Lasiosphæria			
fulcita, *Bucknall*	V.	XIII.	8
Leptosphæria			
culmicola, *Fr.*	V.	XIV.	13
dolioides, *Auers.*	V.	XIV.	14
galiorum, *Sacc.*	V.	XIV.	12

	VOL.	PLATE.	FIG.
Leptosphæria—*continued.*			
Michotii, *West.*	V.	V.	4
microscopica, *Karst.*	V.	VII.	15
nectrioides, *Speg.*	V.	VII.	14
vagabunda, *Sacc.*	V.	VII.	16
Leptostroma			
phragmitis, *Fr.*	VI.	I.	1
Lophiostoma			
pulveracea, *Sacc.*	V.	VII.	12
vagabundum, *Sacc.*	V.	VII.	13
vagans, *H. Fabre.*	V.	XII.	7
Melanconium			
typhæ, *Peck.*	V.	VI.	9
Metasphæria			
corticola, *Sacc. & Speg.*	V.	VIII.	22
culmifida, *Karst.*	V.	XIV.	15
Mollisia			
palustris, *Rob. var.*	VI.	II.	6
Nectria			
arenula, *B. & Br.*	III.	II.	4
dacrymycella, *Nyl.*	IV.	I.	7
erubescens, *Desm.*	III.	IV.	4
Paxillus			
panæolus, *Fr.*	IV.	III.	2
Perisporium			
vulgare, *Corda var.*	V.	XIII.	9
Peziza			
arctii, *Ph.*	IV.	I.	5
echinulata, *Awd.*	III.	IV.	1
excelsior, *Karst.*	IV.	I.	4
fugiens, *Bucknall*	III.	IV.	2
prasina, *Quel.*	IV.	I.	3
Phoma			
equiseti, *Lev.*	IV.	I.	2
Pirottaea			
veneta, *Sacc.*	VI.	II.	9
Pleospora			
vagans, *Niessl.*	V.	VIII.	18
Pseudovalsa			
fusca, *Bucknall*	V.	V.	1

	VOL.	PLATE.	FIG.
Schizostoma			
montellicum, *Sacc.*	V.	XII.	6
Sordaria			
minuta, *Winter*	III.	IV.	6
pleiospora, *Winter*	III.	IV.	5
polyspora, *Ph. & Pl.*	III.	II.	10
sparganicola, *Pl.*	III.	II.	7
„ *var.* velata, *Bucknall*	V.	V.	2
Sphæria			
deflectens, *Karst.*	III.	II.	12
endopteris, *Pl.*	III.	II.	9
italica, *Sacc.*	IV.	I.	10
Sphærella			
Tassiana, *De Not.*	V.	VIII.	19
Sporormia			
secedens, *Bucknall*[1]	V.	V.	3
Stagonospora			
gigaspora, *Niessl.*	V.	VI.	8
Stictis			
pteridina, *Ph. & Buck.*	IV.	I.	6
Trichia			
contorta, *Rost.*	VI.	I.	4
Valsa			
gastrinoides, *Ph. & Pl.*	III.	II.	11
gregaria, *Lib.*	V.	VI.	10
nidulans, *Niessl.*	V.	VI.	11
pustulata, *Desm.*	IV.	I.	9

[1] = Perisporium vulgare, *Corda*.

The following Publications of the Bristol Naturalists' Society may be obtained from any Bookseller, or from the Honorary Secretary.

One Volume, bound, 6s.

FLORA OF BRISTOL.

By James Walter White, F.L.S.

The area of this flora is that included in the geological map of the Bristol coal field, by the late William Sanders, F.R.S., F.G.S.

The Fungi of the Bristol District. By Cedric Bucknall, Mus. Bac.

Part IV.	Species	690 to 836.	4 plates, 3 coloured, 1 black.	1*s.* 6*d.*
„ V.	„	837 to 934.	2 „ 1 „	1*s.*
„ VI.	„	935 to 1023.	1 plate, black	1*s.*
„ VII.	„	1024 to 1084.		6*d.*
„ VIII.	„	1085 to 1144.	3 plates, coloured	1*s.* 6*d.*
„ IX.	„	1145 to 1240.	4 plates	1*s.*
„ X.	„	1241 to 1321.	4 plates	1*s.*
„ XI.	„	1322 to 1362		6*d.*
„ XII.	„	1363 to 1399.	2 plates	1*s.*
„ XIII.	„	1400 to 1431 Index to Parts I. to XIII. and plates		1*s.*

On the Newly-Discovered Phenomenon of Apospory in Ferns. By Charles T. Druery, F.L.S. Illustrated. 1*s.*

Contributions to the Geology of the Avon Basin. By Prof. Lloyd Morgan, F.G.S. I. "Sub-Aerial Denudation and the Avon Gorge." Coloured Map. II. "The Millstone Grit at Long Ashton, Somerset." With Map. 1*s.*

III. "The Portbury and Clapton District." IV. "On the Geology of Portishead." 2 coloured maps and 2 plates. 1*s.* 6*d.*

Sleep and Dreams. By George Munro Smith, L.R.C.P. Lond., M.R.C.S. 2 plates. 1*s.*

The Bone-Cave or Fissure of Durdham Down. By E. Wilson, F.G.S., Curator of the Bristol Museum. 2 plates. 1*s.*

Notes on a Common Fin Whale, lately stranded in the Bristol Channel. By E. Wilson, F.G.S., Curator of the Bristol Museum. Photograph. 1*s.*

The Severn Tunnel. By Charles Richardson, C.E., and Notes on the Geology of the Section by Prof. C. Lloyd Morgan, F.G.S., Assoc. R.S.M. With geologically coloured Section of Tunnel, map and plate. 2*s.*

The Mendips: A Geological Reverie. By Prof. C. Lloyd Morgan, F.G.S., Assoc. R.S.M. 1*s.*

The Arch. By Charles Richardson, C.E., with illustrations. 1*s.*

Portrait and Obituary Notice of the first President of the Society, Mr. William Sanders, F.R.S. 6*d.*

Proceedings, New Series.

Vol. I., Part 1, 1873–74.	4*s.*		Vol. IV., Part 1, 1882–83.	3*s.* 6*d.*
„ „ „ 2, 1874–75.	3*s.*		„ „ „ 2, 1883–84.	3*s.* 6*d.*
„ „ „ 3, 1875–76.	4*s.* 6*d.*		„ „ „ 3, 1884–85.	3*s.* 6*d.*
„ II., „ 1, 1876–77.	3*s.* 6*d.*		„ V., „ 1, 1885–86.	4*s.*
„ „ „ 2, 1877–78.	3*s.* 6*d.*		„ „ „ 2, 1886–87.	5*s.* 6*d.*
„ „ „ 3, 1878–79.	3*s.* 6*d.*		„ „ „ 3, 1887–88.	5*s.*
„ III., „ 1, 1879–80.	3*s.* 6*d.*		„ VI., „ 1, 1888–89.	4*s.*
„ „ „ 2, 1880–81.	3*s.* 6*d.*		„ „ „ 2, 1889–90.	3*s.* 6*d.*
„ „ „ 3, 1881–82.	3*s.* 6*d.*		„ „ „ 3, 1890–91.	4*s.* 6*d.*

ADOLPH LEIPNER, Hon. Sec.

38, Hampton Park, Redland, Bristol.

3 2044 103 126 389

Date Due

~~MAY 1 1948~~

the
vol-
the
nger
han
not
fter
the
ious
oks